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AN EXPERIMENTAL STUDY ON THE FORMATION OF METHANE HYDRATES

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ABSTRACT

Gas(methane) hydrates are solid solutions when water molecules are linked through hydrogen bonding and create host lattice cavities that can enclose many kinds of guest(gas) molecules. There are abundant resources of methane(gas) hydrate in the earth and distributed widely at offshore and permafrost.

The natural gas(or methane) hydrate exists in nature at low temperature above the normal freezing point of water and high pressure greater than relatively 30bars. In the present investigation, extensive experimentations have been carried for these characteristics using a semibatch stirred tank reactor. The temperatures considered in the experiments were in the range of 274.6i 289.5K under to find out equilibrium points 2.90i 15.14MPa. Initially, the experiments have been carried out by increasing temperatures of the cell at fixed pressures. Then, experiments for the influence of gas consumption under various degrees of subcooling and stirring rates has been investigated to determine kinetic characteristics of the hydrates.

The results of present investigation show that the gas consumption rates were closely related to operational pressure, temperature, degrees of subcooling and stirring rates.

Key Words : methane(gas) hydrate, subcooling, operational pressure

I. INTRODUCTION

There have been a number of reports with regard to the abundance of methane hydrates around the world.

Despite the large variation in the sources of methane, it is still believed the most reliable alternative to the petroleum-based fuels. Scientists and engineers around the world are struggling strenuously to exploit this valuable resource more efficiently and more economically[1].

Many research programs involving both field and laboratory are underway in different countries and there have been quite a number of encouraging reports recently concerning the availability of

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methane hydrates as viable energy resources for the future. Japan, Korea, USA, Canada and Norway are some of those countries that already have embarked on ambitious long-term plans to capitalize on methane hydrates under the auspices of the local or central government[2].

The Japanese government was the first in establishing the large-scale national exploratory hydrate research program in 1995. They even sponsored probing in foreign countries. Drilling tests in the McKenzie Delta(a well-known hydrate deposit) in Canada in 1998 supported by the Japan National Oil Corporation is one of those examples. It is believed that the New Energy & Industrial Technology Development Organization (NEDO) will play a vital role in the development and commercialization of methane hydrates as the organization oversaw other energy programs for past decades[3].

In Korea, a systematic effort was initiated in 1996 by a national research laboratory, Korea Institute of Geoscience and Mineral Resources (KIGAM). KIGAM staged a 3 year plan to catch up with the advanced countries in exploring hydrates. Basic studies are done to theoretically analyze hydrates[4]. A number of universities are involved to this end and a network of collaboration was established for the first time, nationally. Cheju National University later joined this network in 2000 when a team of professors was invited by the research group at Inha University which is located in the port city of Incheon(about 40km west of Seoul). Professor C. B. Kim of Inha University was at the center of this research activity[5]. He designed a test facility which can produce and test methane hydrates. They were also able to form an international research network including other foreign countries. Naval Research Laboratory and University of Hawaii of USA are the ones which most closely collaborate with the team. This paper introduces the research facilities made by the team and also presents some of the results produced by using such facilities. The main body of hardware are located at the Thermal Engineering Laboratory at Inha University.

II. EXPERIMENTAL INVESTIGATIONS AND RESULTS

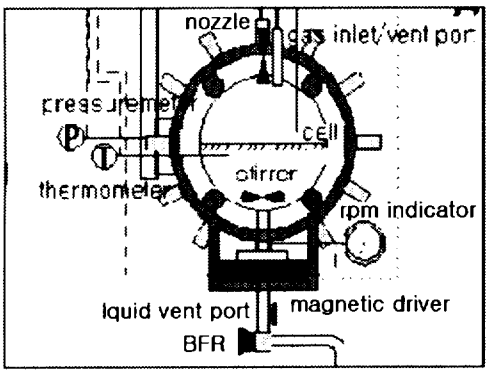
The scope of research was limited to investigate thermodynamic aspects of methane hydrates when they are formed in the small plant of the aforementioned research facilities. Its major areas of research investigation are given below:

1) Formation and decomposition of methane hydrates
2) Analysis on tapping hydrocarbons such as natural gas for storage and transportation
3) Thermodynamic conditions for fast production and high containment of methane hydrates
4) Influence of various physical parameters: temperature, pressure and stirring rate
5) Design of ideal conditions for maximum efficiency

The present study has carried out a series of tests to determine the most suitable conditions with regard to the above enumerated concerns. Equilibrium phases of hydrate formation as well as its decomposition are examined according to the test protocols in the previous studies. This work also investigated different schemes to generate methane hydrate in such a way that it deems more proper than previous methods. Fig. 1 shows the schematic and actual photo of the reaction chamber where methane hydrate crystals are produced[6].

Fig. 2 shows some of the test results obtained in this study, which are worthwhile to note. It clearly describes the stirring effect in the reaction chamber when methane hydrate crystals are formed. In the

beginning, the stirring effect is very much conspicuous, however, this fades out as time elapses. After 5 hours, the case without any stirring shows better performance in forming methane hydrate crystals.



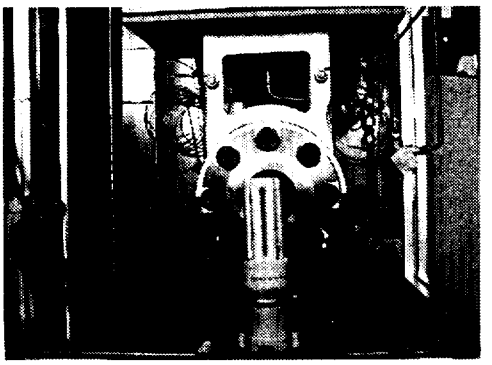
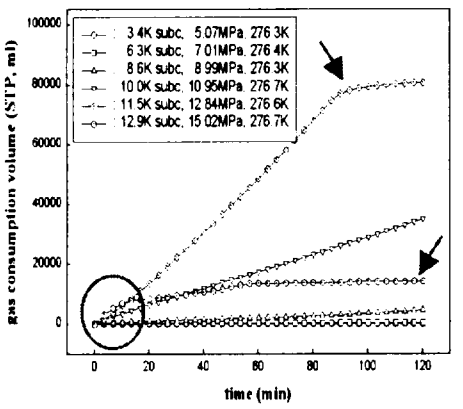


Fig. 1. The experimental apparatus for the formation of methane hydrates.



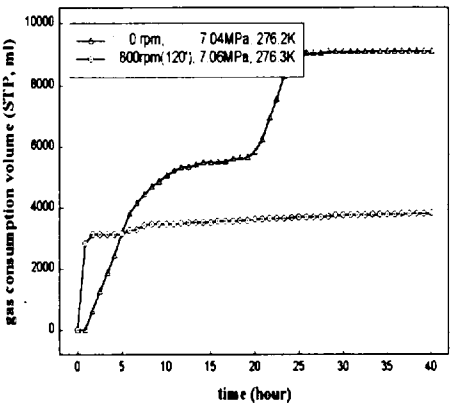


Fig. 2. The test results obtained in the reaction chamber.

III. CONCLUSIONS

This paper briefly describes how methane hydrate crystals could be generated under the artificially made environment. Thermodynamic aspects of the phenomena involved are treated in conjunction with the operation of a reaction chamber designed and fabricated, where adjustments could be made to simulate different possible conditions. More studies are to be done to find the most suitable conditions for the processing of methane hydrates, naturally or artificially.

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