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ScienceDirect

Energy Procedia 105 (2017) 224 – 229

Energy Procedia

The 8th International Conference on Applied Energy – ICAE2016

Influence of Porous Media on Methane Hydrate Formation from Ice Powders

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Abstract

Methane hydrate formation from ice powders is a complicated process, and is affected easily by many factors. In this paper, a series of experiments were conducted to study the influence of porous media's particle size and volume proportion on the hydrate formation process. An experimental system based on PVT method was used to measure the gas consumption and the pressure change through the whole process of reaction. The pressure drop and hydrate saturation were analyzed to show the effects of porous media. The results indicated that porous media not only can improve the discrete degree of ice particles, but also increase the contact area of quasi liquid layer and methane gas. The specific effects of particle size and volume proportion were based on the two effects above.

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.

Keywords: Methane hydrate; Ice powers; Porous media

1. Introduction

Distributed in the outside edge of mainland and permafrost, natural gas hydrate is thought to be a kind of new generation energy which is able to replace traditional fossil fuel and ease the global energy crisis [1]. Methane hydrate can be compounded in laboratory under the condition of low temperature and high pressure. Actually, compounding hydrate in laboratory has become one of the most popular ways to research the properties of hydrate. Methane hydrate formation from ice powders is an important method to research the integrated process of methane hydrate formation. Many researches has been conducted to explore the kinetic of hydrate formation [2, 3]. Staykova [4] and Stern [5] accomplished a series of experiments, laid the foundation of methane hydrate formation from ice. There are several dynamics model to describe the process of hydrate growth, one is retract model [6]. The retract model divide the process of hydrate growth into three continuous stages: the first stage hydrate film form quickly on the

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Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.
doi:10.1016/j.egypro.2017.03.306

surface of ice particles; the second stage hydrate grow around the thin film and gradually form a coating layer on the surface of ice particles; the third stage gas molecules diffuse into the coating layer while water molecules diffuse outside and the formation process continues. Studies about methane hydrate formation from ice powders at home and abroad mainly focused on factors such as ice particle size, temperature, pressure and surfactant [7, 8]. But the formation of hydrate in permafrost is participated by porous media [9, 10]. So it is necessary to research the influence of porous media and this is the objective of this paper.

2. Experiment

2.1. Experimental apparatus and specimen preparation

In this study, a PVT system based on gas consumption during the hydrate formation reaction in a closed ice-gas system was used. The sketch of the experimental system is shown in Fig. 1. The high-pressure reactor was a cylindrical cell with an effective volume of 460 ml and pressure capacity of 30MPa. The pressure was measured by a pressure sensor with an accuracy of ±0.01MPa. In addition, five equidistant (35mm) interfaces of thermocouples were opened along the reactor to measure the temperature. The estimated error of the thermocouple was ±0.1℃. The cold storage provided low environment temperature, and the thermostatic bath was used to keep the temperature fluctuation less than 0.1℃.

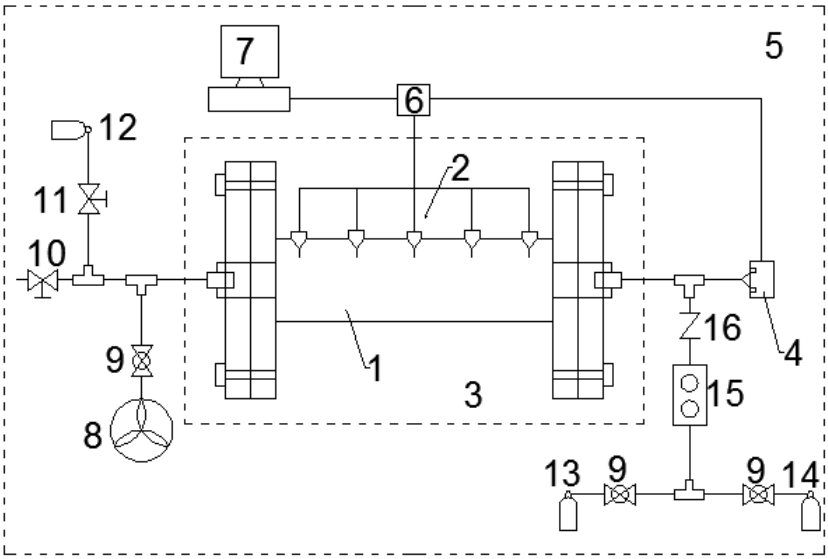

Fig. 2.1. System of the methane hydrate formation apparatus

1- high pressure reactor; 2- thermocouple; 3- glycol-water bath; 4- pressure sensor; 5- cold storage; 6- A/D module; 7- computer; 8- vacuum pump; 9- needle valve; 10- relief valve; 11- reducing valve; 12- waste bag; 13- N_2 cylinder; 14- CH_4 cylinder; 15- flow meter; 16- check valve.

In this study, methane hydrate was formed by mixing methane gas and ice powders within porous media. Methane gas was supplied by a local company Dalian Special Gases Co., Ltd, and the purity is 99.99%. Ice powders were manufactured from freezing deionized water. The whole process of manufacturing ice powders was conducted in cold storage under -10℃ condition. The smashed ice was