GAS HYDRATE INHIBITION AND ITS UNIQUE THERMODYNAMIC BEHAVIORS WITHIN THE POROUS CLAY SEDIMENT

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Key Words: Gas Hydrate; Hydrate Inhibition; Phase Equilibrium; Thermodynamics; Porous Clay;

The fundamental understanding of gas and water system in geological sediments is necessary for greenhouse gas sequestration and future energy production. Depending on the surrounding environments that water, gas, and other substrate material coexist, several unique phases such as supercritical, dissolved gas, gas oversaturated, and hydrate could be formed. Especially, gas hydrates which are composed of water frameworks and several gaseous guest molecules have drawn people's attention for its application such as methane production with carbon dioxide sequestration. For these reasons, to produce methane from natural gas hydrate and store carbon dioxide by replacement reaction, the thermodynamic behaviors of gas hydrate and its stability have become an important issue. Therefore, in this study, we investigated the physicochemical behaviors of intercalated gas hydrate such as unique dissociation patterns, cage occupancy, and phase equilibria in depth. Moreover, we suggested the precise location where gas hydrates are formed within the clay sediment considering the effect of unique surroundings and pore dimension. To analyze the effect of interlayered structure and pore dimension of clay on properties of gas hydrate, Na-montmorillonite and aluminum pillared clay (aluminum pillared montmorillonite) were used and compared.

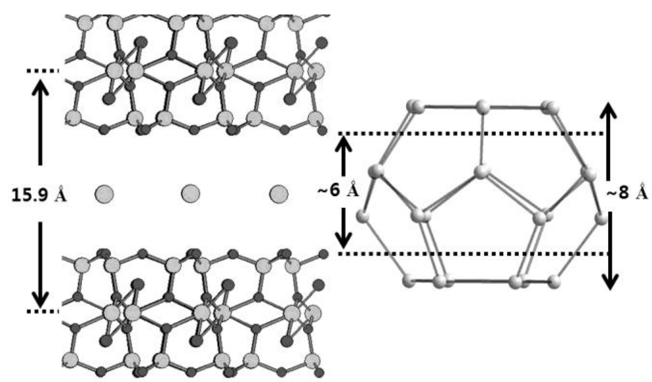

Figure 1 – Schematic illustration of the structure of clay sediment and 5^{12} hydrate cage with their dimensions

BOILING HEAT TRANSFER ENHANCEMENT BY NANO-PARTICLES-ASSEMBLED BI-POROUS LAYERS

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Key Words: Bi- porous layer, High heat flux, Boiling heat transfer, Saturated pool boiling

Nanoparticles-assembled bi-porous structure is newly proposed as boiling heat transfer enhancement technique. In order to assemble nanoparticles onto a heat transfer surface as a thin layer, a boiling adhesion method (BAM) is originally introduced in which, water or water/ethanol solution with mono-dispersed nanoparticles is dropped or sprayed onto a high temperature surface, and then the nanoparticles deposit onto the heat transfer surface during the boiling. In addition to that, it is expected that boiling bubbles can produce micro or milli scale of larger pores at the same time, which enables to fabricate bi-porous structure.

In order to evaluate the boiling heat transfer performance of the bi-porous surface, the boiling curve is obtained under atmospheric and pool boiling conditions. The nanoparticles we used are aluminum oxide ones with the average diameter of 31 nm. The experimental results show that the boiling adhesion method can produce multi-scale pore structures composed of nano-scale pores and micro-scale pores and that the bi-porous layer can enhance the critical heat flux.

EXPERIMENTS OF WATER'S EFFECT ON MECHANICAL PROPERTIES OF SHALE ROCKS

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The multiple hydraulic fracturing is an indispensable means to improve the production mass of natural gas in development of shale gas. The fracturing water consumption of a horizontal well reaches 10x103 m3. However, the water been injected into shale layer is not reverse discharged completely. How does this part of water stays in shale layer? What's the role it plays? And how does it have any effects on the development? We studied effects of water on shale rock mechanical properties experimentally to answer these questions.

1 Water Imbibition Experiments of Shale Rock

Experiments show that: the imbibition in surface of shale slice is very big. The mass imbibition rate is about 17%, and volume imbibition rate is about 43% which far more than porosity of shale rock of 3%. The reason is there is a water layer of 3um height adhesion at surface of shale rock because of hydrophilic surface. The moving imbibition of water can be observed by super-field depth optical microscope (shown in figure 1).

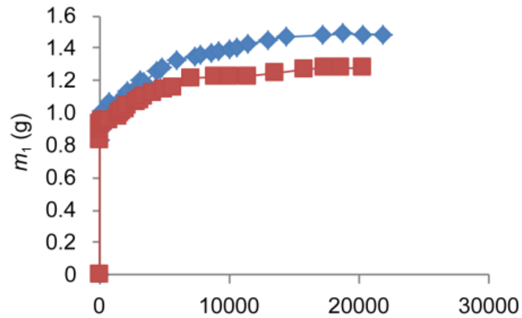

Fig.1 water imbibition on surface of shale rocks

2 Change of Shale Rock's Fracture Strength after Water Saturation

Experiments show that: after water saturation, the fracture pressure is greatly reduced from about 30.9MPa to 10.4MPa(shown in fig.2), and it is conducive to produce fracture system, so the production rate of shale gas can be improved. The imbibition water rate is about 7% of volume bigger than porosity of shale rocks because of the hydrophilic surface.

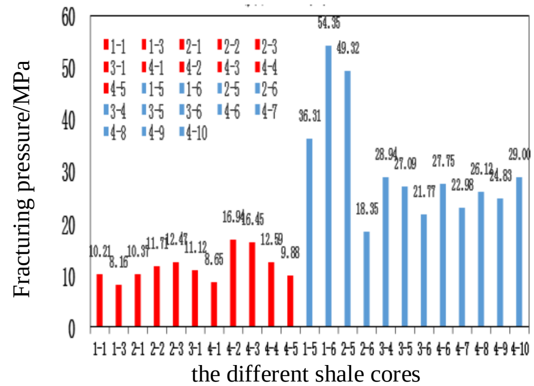

Fig.2 shale's fracturing pressure (blue is dry shale core, red is water saturated shale core)

AN EXPERIMENTAL INVESTIGATION ON EFFECT OF PORES PER INCH IN COMPACT HEAT EXCHANGER WITH ALUMINUM FOAM

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Key Words: Compact Heat Exchanger, Aluminum Foam, Experimental Heat Transfer Rate

Metal foams are a new class of materials with low densities and novel thermal and mechanical properties. Aluminum foams combine low weight with good rigidity, strength, damping of vibrations and noise, shock resistance and low thermal conductivity [1]. An experimental investigation on a single row of aluminum tubes, covered with layers of aluminum foams, was carried out by T'joen et al. [2]. A range of foam layer thickness, Reynolds number tube spacing and different type of foam were considered and compared with compact helically finned tube heat exchangers. An experimental investigation was carried out by Sertkaya et al. [3] to compare three metal foam heat exchangers (10, 20 and 30 PPI) to three finned heat exchangers with the same tube layout and overall dimensions. Results showed that the finned heat exchangers furnished a higher heat transfer and a lower pressure drop than the foamed heat exchangers. A numerical analysis to evaluate the performance of metal foam heat exchangers and compare it to the performance of a bare tube bundle and of an existing conventional louvered fin heat exchanger was presented by Huisseune et al. [4]. It was found that, at the same fan power, the foamed heat exchangers show up to 6 times higher heat transfer rate than the bare tube bundle. The aim of the present experimental investigation on a air-water aluminum foam heat exchanger is to evaluate its thermal and fluid dynamic characteristics. Results are given for different pores PPI (10, 20 and 30 PPI), porosity equal to 0.93 metal foam and air mass flow rate in a range of laminar flow

The features of heat transfer related to the aluminum foam heat exchanger, in terms of convective average coefficient and Nusselt number, is carried out. The hot fluid is water and it flows in internal tubes placed inside the metal foam, the cold fluid is air. The air enters inside a duct where is placed the heat exchanger, through a convergent channel, on the right of the upper part. The duct has a square transversal section of 220 mm x 220 mm and 760 mm long, the convergent duct is 454 mm long and it has the squared transversal inlet and outlet sections equal to 490 mm x 490 mm and 220 mm x 220 mm, respectively. Air motion is obtained by means of a fan, which is modulated by a valve, in order to obtain different air flow rates. At the end of this duct there is the heat exchanger. A series of pipes allows to reduce the section from 160 mm, downstream the fan, to 36 mm at the exit section of apparatus in order to obtain a more accurate measurement of the velocity. To evaluate the pressure drop a digital manometer is used. The measurements are obtained estimating the pressure upstream and downstream the heat exchanger. Steady state for a heat exchanger is reached later for hot fluid at 50°C than for 60°C and 70°C. The heat transfer rate is a function of flow rate. In particular, it increases until it reaches a critical value beyond which, also increasing the flow rate the thermal power tends to remain constant.

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