Journal of Natural Gas Science and Engineering 26 (2015) 921–926

Contents lists available at ScienceDirect

Journal of Natural Gas Science and Engineering

journal homepage: www.elsevier.com/locate/jngse

Designing a Polyacrylate drilling fluid system to improve wellbore stability in hydrate bearing sediments

Ali Fereidounpour [a], Ali Vatani [b, *]

[a] School of Chemical Engineering & Institute of Petroleum Engineering, University of Tehran, Tehran, Iran
[b] School of Chemical Engineering & Institute of Liquefied Natural Gas (I-LNG), University of Tehran, Tehran, Iran

ARTICLE INFO

Article history:
Received 9 January 2015
Received in revised form
22 June 2015
Accepted 23 June 2015
Available online 17 July 2015

Keywords:
Hydrate
Sediments
Drilling fluids
Wellbore stability
Polyacrylate

ABSTRACT

Natural gas hydrates, preserved in deep ocean sediments, are believed to be a new energy source for future needs. But, when drilling through hydrate bearing sediments (HBS), thermal stimulation and depressurization may cause hydrate dissociation and the resultant wellbore instability plus other drilling hazards such as severe mud gasification, partial washout and caving, casing running problems and casing subsidence. A new drilling fluids system using Polyacrylate derivatives has been designed to improve wellbore stability during drilling. An experimental setup was designed and manufactured to investigate the effects of Polyacrylate drilling fluid when it comes in contact with HBS. The Polyacrylate fluids reduce the heat exchange rate to prevent gas hydrate dissociation and its resultant hazards. They also reduce the invasion of the drilling fluids into the formation and covering the wellbore wall by a polymer bond. In addition, Polyacrylate adsorbs the free water around the wellbore. Hence, the use of the designed Polyacrylate drilling fluids can reduce the risks of drilling through HBS.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Hydrates are crystalline compounds, composed of water molecules, which trap low-weight gas molecules within their cage-like structures. Natural gas hydrates indicate stability in the range of low temperatures and high pressures, called hydrate stability zone (Fig. 1). These conditions are usually found in permafrost regions and deep-water seas (Sloan 1998).

Hydrates are a threat to the drilling industry rather than being an energy source. During the drilling operation, heat transfers to hydrate formations, which may result in the hydrate dissociation. Drilling fluid gasification, wellbore instability (wall diffusion), wellbore washout and widening, formation failure and casing subsidence, and personnel health risks are examples of hazards which may occur during drilling operations in hydrate bearing sediments of deep waters. Another concern is leaking gas from dissociated hydrates to the sea floor or other formations which may bring hazardous consequences to personnel and the drilling platform.

One of the three main mechanisms of hydrate production is providing heat. Hong et al. (2003) studied gas production from hydrates in porous media. They proved that hydrate safety and efficient production is mainly governed by heat transfer.

Necessary heat provision for hydrate dissociation is one of the main requirements of any production technique, which is determined by heat transfer. Drilling operations causes hydrate instability, and result in hydrate dissociation (Pooladi-Darvish and Hong, 2004). Iida et al. (2001) examined Tetrahydrofuran-hydrate (THF) formation and it's thermally dissociation in a one-dimensional system under atmospheric pressure. The heat transfer at the hydrate–solution interface was investigated across the hydrate and solution. The experimental data also show a general agreement with that predicted by theoretical analyses of transient conduction at the hydrate–solution interface.

Birchwood et al. (2005) used a prototype mechanical wellbore stability model to calculate the mud weight window representing the zone of mechanical stability of wellbores in sediments containing gas hydrates. Freij-Ayoub et al. (2007) used a model which couples the thermodynamic stability of the hydrates in porous media to mass and heat transport and mechanical deformation criteria. Khabibullin et al. (2011) combined a 1-dimensional model of mass and heat transfer with a wellbore temperature distribution model to investigate hydrate dissociation and its impact on wellbore stability.

* Corresponding author.
E-mail address: avatani@ut.ac.ir (A. Vatani).

http://dx.doi.org/10.1016/j.jngse.2015.06.038
1875-5100/© 2015 Elsevier B.V. All rights reserved.

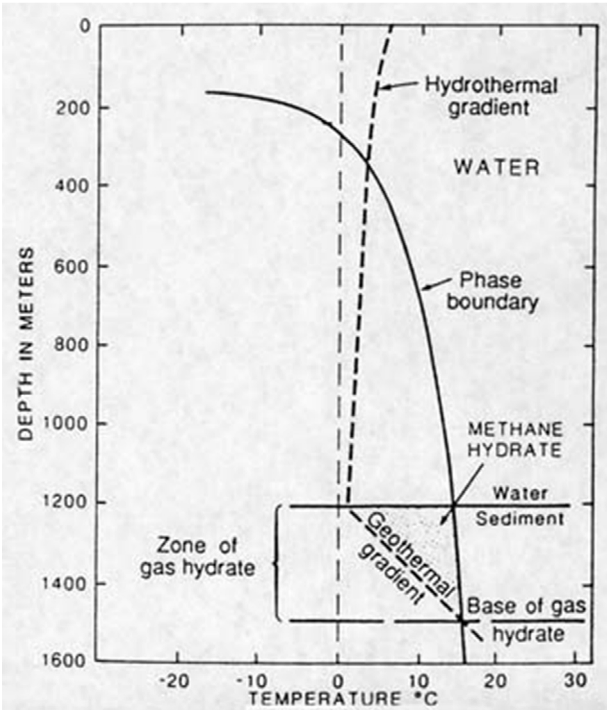

Fig. 1. Methane hydrate stability zone (Kvenvolden. 1993).

Fereidounpour and Vatani (2014) designed a reactor and conducted a series of experiments to evaluate interaction between drilling mud and THF-HBS which came to the conclusion that the use of polymers such as PHPA and PAC in drilling fluid reduces the rate of hydrate dissociation.

All in all, drilling in hydrate bearing sediments can lead to hydrate dissociation due to high temperature of drilling fluid and the resultant hazards and costs. Due to the limited experimental studies conducted on hydrate dissociation during drilling, several parameters are not fully understood and a number of significant subjects remain unsolved. The aim of this research was to evaluate other Polyacrylate derivatives effect in different mud formulas to find the best one for halting hydrate dissociation.

In this research, a 6 L volume reactor was served to investigate the heat transfer characteristics of hydrates in porous media during the dissociation process in a closed reactor by a thermal method. Three thermal resistance thermometers were distributed uniformly in a linear direction in the reactor. The hydrate decomposes at a different rate when it comes in contact with different drilling fluids in a closed reactor. The relation of temperature difference of the different positions in the linear direction and the hydrate dissociation rates were obtained. The characteristics of THF hydrate decomposition were also investigated.

2. Methodology

This section describes the designed apparatus to evaluate THF-hydrate behavior when it comes in contact with high temperature drilling fluid. Furthermore, the hydrate formation and dissociation has been explained. At the end of this section, rheology and filtration properties of the designed mud have been shown.

2.1. Apparatus

The experimental apparatus was constructed as to enable linear simulation of THF hydrate dissociation. Fig. 2 illustrates the test cell and the main section of the apparatus, in which aqueous THF solution is mixed at a specific molar ratio with various sizes of consolidated sediments, and then, cooled into THF hydrate. The test cell was made of Steel, and after phosphating, all of its surfaces became stainless. The dimensions of the test cell are: OD = 155 mm, ID = 111 mm and L = 580 mm. To record pressure and temperature values, four pressure transducers and four thermocouples were installed on the test cell with 6 cm spacing. To provide an appropriate environment for hydrate formation, 16 holes were embedded in the reactor mantle for coolant fluid circulation. A 1/2 inch inlet was perforated at the upstream cap, provided a conduit for drilling fluid into the test cell. At the bottom of the test cell, a 3/8 inch outlet was devised for drilling fluid circulation, providing a drain for drilling fluid and washed out sediments. Schematics of the reactor and the experimental setup are illustrated in Figs. 2 and 3. Experimental set up of the hydrate evaluation test is shown in Fig. 4.

There are many affecting factors on dissociation of hydrate during drilling that can be investigated by our special setup such as drilling fluid temperature, pump flow rate, mud additives, margin pressure, mud invasion zone, and etc. One of the main limitations of this setup is that the experiments cannot be conducted at elevated pressures; therefore, methane hydrates cannot be formed and investigated using this setup. Methane hydrates can be formed by modifying the setup and applying overburden pressure, which will be studied in future by our research group.

2.2. Procedure

As can be seen from Table 1 mechanical and thermal properties of methane hydrate and THF hydrate are similar. Hence, THF-Water solution was used to form hydrate to avoid risks which may be caused by using methane.

During drilling through a gas hydrate bearing sediments, hydrate is dissociated into gas and water and carried up by the drilling fluid. The hydrate dissociation occurs because of the changes in the temperature or pressure of hydrate, when it comes in contact with the drilling fluid. Also, the use of thermodynamic inhibitors such as salts in drilling fluids causes hydrate dissociation. The thermal stimulation of hydrate was studied through this work, but other factors were not considered.

2.2.1. Hydrate formation

Sand was the main material used in the experiment. First, the grain mixture was saturated with aqueous THF solution with a certain proportion, and the mixture was tightly packed in the

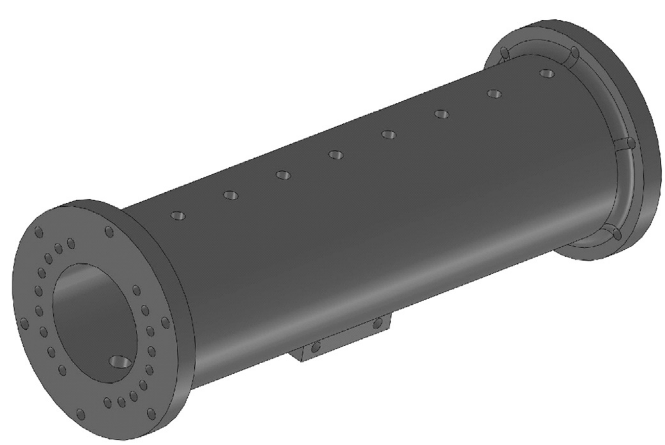

Fig. 2. Schematic of test cell.

Download English Version:

https://daneshyari.com/en/article/1757584

Download Persian Version:

https://daneshyari.com/article/1757584

Daneshyari.com