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AN OVERALL APPROACH FOR DESIGNING AND EXTRACTING THE GAS HYDRATE WELLS

Reddy kalyani
Student
Dr. T. Anil kumar
Sr. Assistant professor
Petroleum engineering
Aditya engineering college
Surampalem

Abstract:

Gas hydrates are ice like structures that hold copious amounts of hydrocarbon. Of great interest to the energy interest are methane hydrates, which are also most abundant in nature. Methane gas hydrates is unique source of methane gas in which gas is caught in crystalline ice like structure in permafrost regions and under the sea. The total amount of carbon present in this unique source far exceeds the conventional fossil fuels. A volume of hydrate contains gas that will expand to somewhere between 150 and 180 volumes at standard pressure and temperature. As exploration and development activities have moved into deeper water, gas hydrates are an increasingly important concern. This paper summarizes the gas hydrates identification, exploration and geological survey techniques.

Introduction:

Gas hydrates are a crystalline or ice-like structure that forms a cage around a molecule of gas. The water molecules are bonded to form the structure and, in this case, a methane molecule is trapped inside. The gas that is trapped can be methane, carbon dioxide, hydrogen sulfide and some smaller hydrocarbon molecules like ethane, butane, and propane. The cage can take several forms. All three have been observed in nature, but they can also be synthesized in the laboratory. The interest in methane hydrates as a potential resource results from the trapping capability of the hydrate structure. Essentially, hydrates concentrate gas by a ratio of 1:160. It means, in one cubic foot of hydrate, about 160 cubic feet of gas is trapped. This would be 160 cubic feet at standard temperature and pressure.

The worldwide organic carbon in the gas hydrates is far more than the carbon content in total fossil fuel

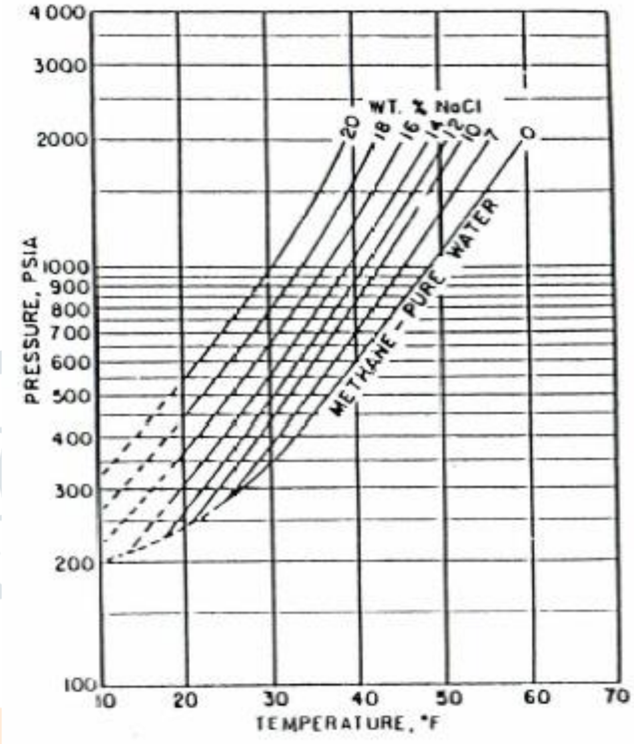
For hydrates to from, several ingredients are necessary. Water will form the cage and gas was filled the cage. The reason that hydrates are of interest in deep water is that they also need high pressures and low temperatures. In addition, a nucleation site is required. The nucleation site would be a surface such as a grain of clay or a pipeline or a piece of platform. This is why you don't find have hydrates floating around in seawater

The USGS has estimated the trillion cubic feet of methane trapped in hydrates. The Alaska Offshore Province has the largest percentage of the resource and the Gulf of Mexico has the least.

THE RESPONSE OF GAS HYDRATES TO LOGGING EQUIPMENT

As gas hydrates and water ice permafrost have the same responses for the standard suite of logs these become major issue in detecting hydrates from well logs. Due to thawing by the drilling mud and subsequent enlargement of the hole in the unconsolidated forms hole conditions for logging is poor. The litho logy and porosity can be interpreted with the help of gamma-ray, neutron logs and density logs.

Both water-ice permafrost and gas hydrate are non-conductive and the pore spaces filled by solid ice or hydrate can be estimated with the help of resistivity log. The formation water salinity is the major source, for the error of the estimation. The conductivity can be seen with the help of logging tool by assuming that some remains unfrozen. The salinity content is observed to be low in shallow



—Effect of salt solution on hydrate formation.

depths and in the range of 2000 to 6000ppm.

The high acoustic velocity and high resistivity log readings and saturation calculations attempted can identify below the base of the continuous permafrost. Hydrates within permafrost are very difficult to distinguish from water-ice. Mud logs may give some indications and carbon/oxygen or nuclear-magnetic resonance type logs might work if hole conditions are suitable.

Due to uncertainties in salinity and temperature at 2000feet, the possible error in calculated water saturation could easily be a factor of two; there is lack of core laboratory studies to quantify the range of hydrate saturations or the parameters suitable for use in log saturation calculations.

When compared with unfrozen formations the gas hydrates and ice permafrost on the north- slope show high acoustic velocities, low transit time. Base permafrost is usually picked where the resistivity reduces to a consistent value less than about 50ohm and the sonic transit time at that point increases in the sands from around 100µs/ft to140-150µs/ft.

One result of drilling through hydrate-bearing strata is to thaw the hydrates in the near wellbore zone through the circulation of drilling fluids warmer than reservoir temperatures. Prior to the advent of MWD (Measurement While Drilling) techniques, wire line logging runs were typically not recording the effects of in situ hydrates due to significant thawing while the drill string was tripped out of the well, and wireline tools run in to the zone of interest. Only the most recent wells in the Barrow (ancient burial mound) Gas Fields were logged with MWD tools, and direct evidence of in - situ hydrates are weak or non-existent in the Barrow Gas Field wells.

ESTIMATION OF GAS HYDRATES CONCENTRATION

The two key terms:

Saturation and concentration are discussed here, while defining gas hydrate concentration estimation methods. Hydrate saturation (Sh) is the volumetric fraction of hydrates present in the pore space and the hydrate concentration (Shyd) is the volumetric fraction of hydrates in the sediments. The relation between the hydrate concentration and hydrate saturation is established by the following equation:

$$S_{hyd}=\emptyset S_h$$

The following methods are commonly used in the estimation of gas hydrate concentration:

1) Seismic or elastic properties
2) Electrical resistivity
3) Chloride measurements of pore fluid
4) NMR-Density porosity
5) Density
6) Temperature

1) SEISMIC OR ELASTIC PROPERTIES

To remotely sense the presence of gas hydrates in marine sediments, seismic reflection data have been historically used. The BSR (bottom stimulating reflector), which represents the base of the gas hydrate stability zone (GHSZ) and mimics the sea floor are the most common seismic proxy for gas hydrates. The BSR is caused by strong acoustic impedance contract between the overlying hydrate bearing sediments and the underlying gas charged sediments.

Gas hydrates concentration within the sediments is commonly estimated with the help of p-wave velocity (V_p). In some cases hydrates are present in low quantity. In such cases Vpand Vs (s-wave velocity) or ratio Vp/Vs (Poisson's ratio) may provide better constraints on the estimation. To distinguish the effect of free gas and hydrate in such cases where free gas exists within the GHSZ, Vs is require along with Vp

Seismic velocities can be estimated from sonic logs (1D), seismic data (2D and 3D) and laboratory tests.

Several authors have presented relationship between seismic velocity and gas hydrate concentration, which can be broadly, grouped into two categories. 1) Empirical relations and 2) Rock physics based effective medium theory. The p-wave velocity of host sediments is increased due to the presence of hydrates in the pore space. The nature and concentration of concentration of hydrates within the sediment effects the s-wave velocity commonly used.

Empirical relationship between Vpand saturation are:

$$\frac{1}{V_p}=\frac{\emptyset\, S_w}{V_w}+\frac{\emptyset S_g}{V_g}+\frac{\emptyset S_h}{V_{hp}}+\frac{1-\emptyset}{V_{mp}}$$

And

$$\frac{1}{\rho V_P^2}=\frac{\emptyset S_w}{\rho_{w}V_w^2}+\frac{\emptyset S_g}{\rho_{g}V_g^2}+\frac{\emptyset S_h}{\rho_{h}V_{hp}^2}+\frac{1-\emptyset}{\rho_{m}V_{mp}^2}$$

Lee et al (1996) present a weighted means of the words and time-average equation as

$$\frac{1}{V_p}=\frac{W\emptyset(1-S_h)^m}{V_{p1}}+\frac{1-W\emptyset(1-S_h)^m}{V_{p2}}$$

Vp from modified wood equation

$$\frac{1}{\rho V_p^2}=\frac{\emptyset_m S_w}{\rho_w V_w^2}+\frac{\emptyset_m S_g}{\rho_g V_g^2}+\frac{1-\emptyset_m}{\rho_m V_{mp}^2}$$

Where,

$$\emptyset_m=\emptyset-S_{hyd}$$

The s-wave velocity can be empirically derived. Following hydrate formation model ofMr.Kumar (2007) Vs can be derived from Vp as follows

$$V_s=V_p\left((1-\emptyset_m)\frac{V_{ms}}{V_{mp}}\right)$$

Vs can be estimated according to Mr. Lee (1996) as

$$V_s = V_p \left[\left[(1-\emptyset)\frac{V_{ms}}{V_{mp}}\right] + \emptyset S_h \frac{V_{hs}}{V_{hp}}\right]$$

Nomenclature:

Vp: P-wave velocity
Vs: S-wave velocity

ELECTRICAL RESISTIVITY

Gas hydrate, like ice, acts as an electrical insulator. The presence of gas hydrates in pores (meaning pores are filled with water and/or gas hydrate) causes the high resistivity above the BSR. Hydrate saturation can be estimated by Archie's law (An empirical law which relates, for a clay-free sediment, the electrical resistivity ρ of a porous rock containing water and cement to the fraction of the pore space that is filled with water. $\rho = \rho o^{-m} S^{-n}$, where ρo is the resistivity of the water and s is the fraction of pore space filled with water.) as proposed by Mr. Lu and Mr. Mc Mechan (2002).

$$S_h = 1 - S_w = 1 - \left(\frac{R_o}{R_t}\right)^{n^{-1}}$$

The critical factor for hydrate concentration estimation using resistivity data is choosing the base line indicating hydrate free sediments, which is depend on pore water salinity.

Well log is used to measure the resistivity directly. Resistivity can be estimated from electromagnetic survey. For mapping gas hydrate in marine environment Controlled Source Electromagnetic (CSEM) survey has been used recently.

CHLORIDE MEASUREMENTS

The chloride anomaly is used to estimate the gas hydrate saturation in the pore space before recovery as

$$S_h = \frac{1}{\rho_h}\left(1 - \frac{Cl_{pw}}{Cl_{sw}}\right)$$

The core samples extracted during drilling were subjected to chloride measurements, but the core recovery without damaging it, maintaining in situ conditions in laboratory, and finding the right background chloride concentration are some of the difficulties, in which hydrate concentration estimation with chloride measurements are difficult .

NMR-DENSITY MEASUREMENTS

Nuclear Magnetic Resonance (NMR) logging tool has the ability to measure water filled porosity and density porosity measure space occupied by both water and/or gas hydrate. The hydrate saturation is measured as (Mr. Lee ,2000).

$$S_h = 1 - \frac{NMR\_porosity}{DENSITY\_porosity}$$

DENSITY MEASUREMENT

The density of rock reduces due to the formation of gas hydrates, assuming original pore space filled with gas hydrate, the saturation of gas hydrate can be estimated by knowing the background rock data$(\rho o)$for water-filled pores and measured the density of hydrate bearing rock (ρ) as

$$S_h = \frac{1(\rho_o - \rho)}{\emptyset(\rho_w - \rho_h)}$$

TEMPERATURE

The dissociation of gas hydrate is an endothermic process. The negative temperature anomaly is created when gas hydrate dissociates, sediment containing hydrate is cooled relative to surrounding sediment (Mr. Ford, 2003). In deep sea drillings, infrared thermal imaging camera has been used to image sediment cores and negative temperature anomaly (average 40C cooler) has been indentified due to gas hydrate.

Techniques for exploration of gas hydrates

The factors affecting the exploration techniques are mainly the temperature and pressure. Depending upon the technique we use these parameters varies. The main concept behind this exploration techniques are the heat of dissociation should be greater than heat of formation. The three novel techniques of extraction of gas from natural gas hydrates are

1) CO_2 sequestration (Gas Exchange)

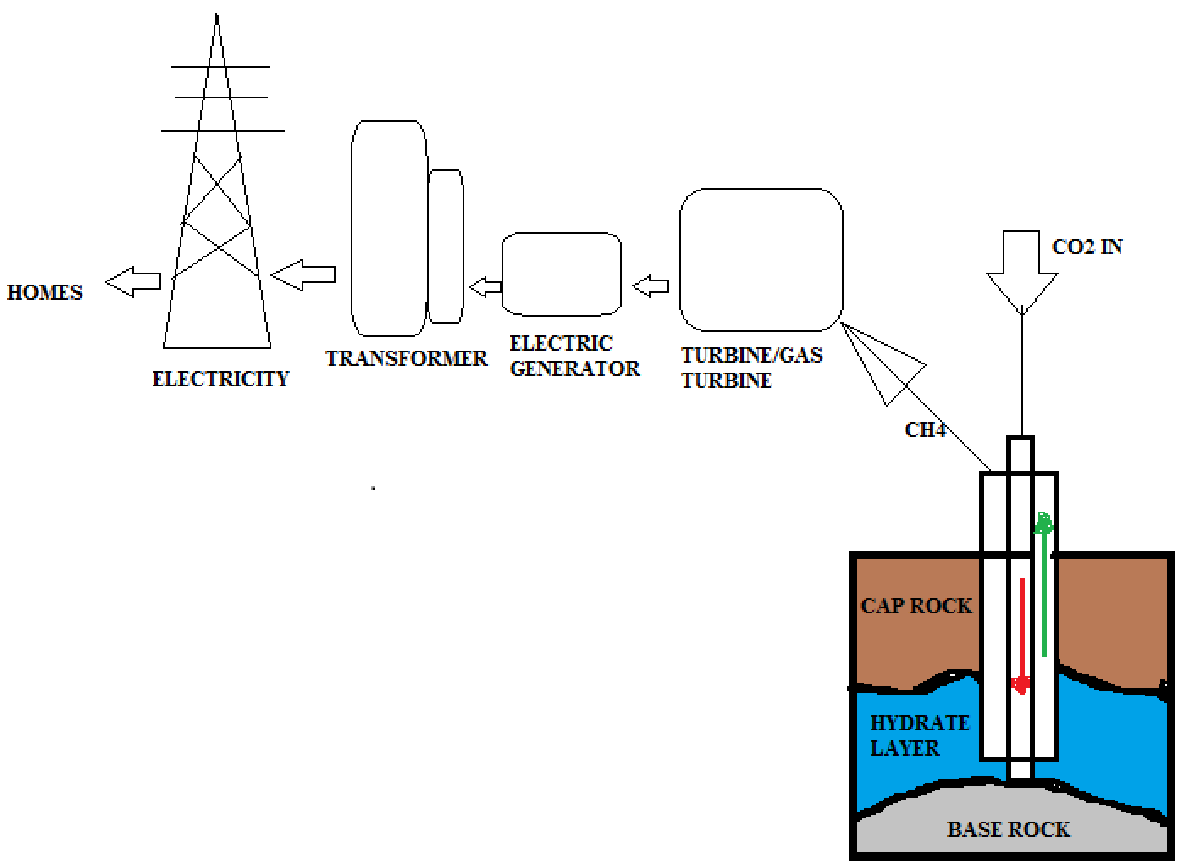
2) Microwave technology

3) Fluorine gas and Micro wave technology

These are explained as per the following details:

1) CO2 Sequestration (Gas Exchange):

This technique achieves the two positive results in a single process i.e., extraction of natural gas from gas hydrates and removal of CO2 from atmosphere. This technique exploits the greater solubility of CO2 in water to displace natural gas. The experiment observed there is a preference for CO2 hydrate over. CH4 is in hydrate phase. Not only equilibrium consideration but the heat of CO2 hydrate formation (-57.9 kJ/mol) is more than the heat of dissociation of CH4 (54.5 kJ/mol), which is favoring for the natural exchange of CO2 with CH4 hydrate, because the above change process is exothermic. A mixture of CO2 and N2 can also be tried for exchange with CH4 from gas hydrate. The technology of gas exchange is shown as per the following figure.



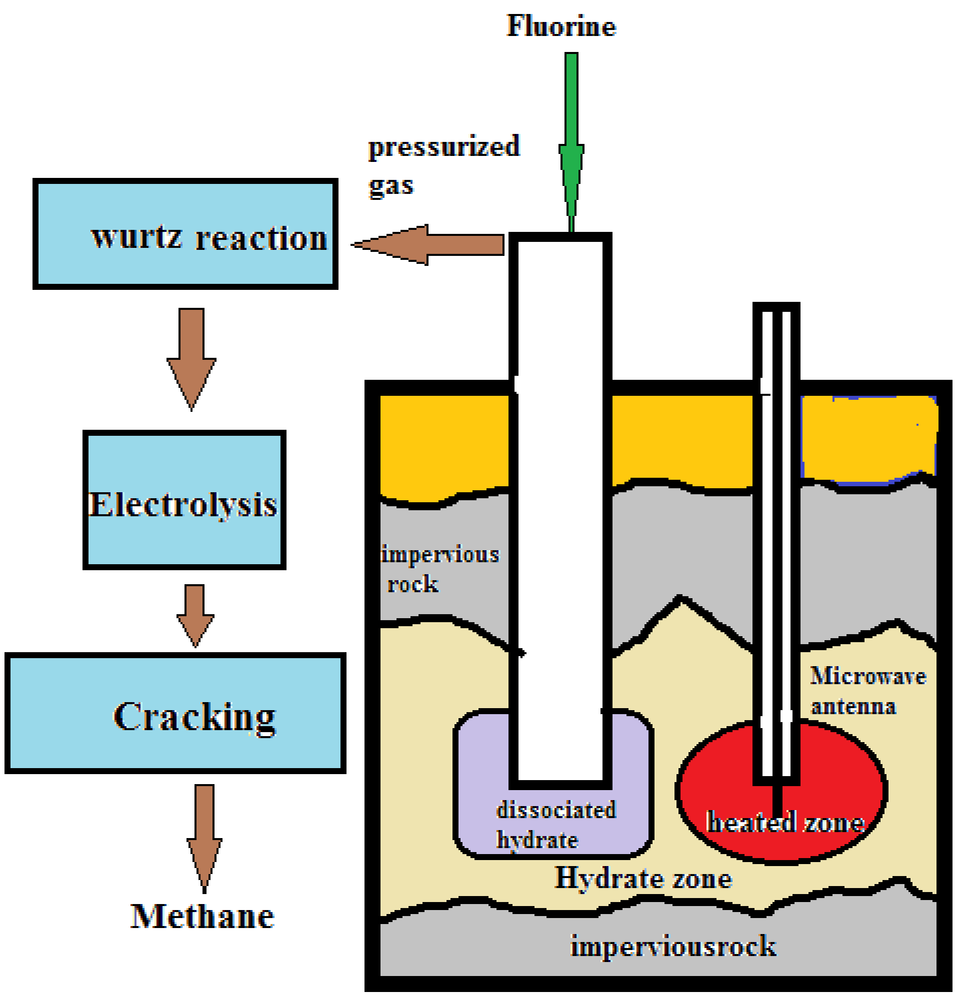
2) Micro wave technology:

Microwaves can pass through materials and deposit energy; heat can be created throughout the volume of the material. So, it can decrease processing times and prove to be energy efficient. Firstly water is heated by microwave which heats hydrates and dissociates the hydrates and this phenomenon of bulk heating leads to high decomposition efficiency. Decomposition water created while the hydrate decomposition enhances hydrate decomposition, and the decomposition water and microwave have a synergic effect on the hydrate decomposition. Gas hydrate can be decomposed and dissociated soon with microwave. The more the power is, the greater the decomposition rate is. However, there is a heat efficiency issue generated from the more system temperature. The microwave heating results into very soon decomposition of gas hydrate compared to other methods. The hydrate decomposition with microwave is a joint effect of numerous mechanisms.

- With the same pressure, microwave can enhance the phase equilibrium temperature.
- While the microwave radiation, there is a linear relationship between temperature and time. The rate of hydrate dissociation increases with increasing microwave power.
- The energy ratio of microwave heating is more than that of water bath heating, but it is lower than the theoretical value of thermal stimulation production.
- Selective heating is possible with microwave. Microwave also increases permeability and porosity.

3) Fluorine gas and Micro wave Technology:

In this method a micro strip antenna with huge power gain and is inexpensive is used with wire line, the tool is placed in well bore and a frequency of 2450 MHz is generated which melts the gas hydrate into water and methyl radical which destabilizes the thermodynamic condition and after this fluorine is injected which results into halogenations which is strongly exothermic and releases -431 KJ/mol and methyl fluoride is soluble in water and the solubility is 166 cc per 100 ml of water. This pressurized gas can be obtained via tubing from production well. After this by applying *Wurtz reaction (*The Wurtz reaction, named after Charles-Adolphe Wurtz, is a coupling reaction in organic chemistry, organometallic chemistry and recently inorganic main group polymers, whereby two alkyl halides are reacted with sodium metal in dry ethereal solution to form a higher alkane: $2R–X + 2Na \rightarrow R–R + 2Na^{+}X^{-}$) , electrolysis and cracking, methane can be recovered. This method enjoys the advantage of green technology because methyl fluoride is eco-friendly. No extra heat is introduced into the reservoir. The diagram of this technology is shown Figure.



Conclusions:

The huge amounts of natural gas stored in the methane hydrates of the Earth's crust can be considered as a future sustainable energy source, provided that environmental risks are taken into account.

Conclusion to Logging section: The topics covered in this section helps us to find the hydrate source by utilizing the different types of techniques available and more new technologies has to bring in future by removing the obstacles in past and present.

Conclusion to estimation section: There are various direct and indirect methods for estimating gas hydrate concentration. The reliability of the gas hydrate concentration will depend on 1) the quality of

measured data, 2) Reliability of the relationship between the rock's physical property (e.g., seismic velocity, resistivity) and gas hydrate concentration, 3) Background property values in the absence of gas hydrates, and 4) *in situ* conditions. If there is any discrepancy among hydrate concentration estimated from different data and methods, one should look at all the four issues

Conclusion to Exploration section:

Even a small percentage of which could meet the e energy requirements of the world for centuries. However, there is a strong need to prepare a suitable viable economic and green commercial technology for exploiting this untapped energy resource.

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