MPD could tap huge quantities of methane hydrate

THE PRESENCE OF hydrates has primarily been a nuisance or a well control issue when drilling for conventional oil and gas offshore and in onshore permafrost regions. However, methane hydrates could very well become the new source of clean and affordable gas supplies in the US by 2030.

For example, if several large "sweet spots" of hydrates could be defined and developed in US waters, the ultimate recoverable hydrate resource could range from 1,500-2,000 Tcf of gas. This is close to the current US domestic natural gas recoverable resource, yet it may be less than 1% of the total in-place methane hydrate resources of the US.

To achieve the long term goals of the US Federal government in regard to energy supplies for the US, the Department of Energy (DOE) is committed to developing the knowledge and technology base to allow commercial production of methane from domestic hydrate deposits by the year 2015.

Under changing geological conditions hydrates can dissociate and be released gradually or explosively, depending upon how rapidly the pressure drops or the temperature increases.

In addition to hydrates being only quasi-stable, the crystal structure of a hydrate packs methane so efficiently, depending upon the purity of the hydrate, it can contain between 70 to 164 times the volume of free gas at standard temperature and pressure compared with the volume of the hydrate prior to dissociation.

Methane hydrates contain enormous volumes of natural gas and are now known to accumulate worldwide on the slopes of continental shelves and below the Arctic permafrost where pressures and temperatures are suitable and methane and water are available.

The existence and thickness of hydrates zones are determined by the influx of gas and water through shallow sediment, the rapid accumulation of organic rich sediments, the geothermal gradient, the water depth and sea-bottom temperature, and the gas mixture of the hydrate. Analysis indicates hydrates can occupy as much as 500 m of sediments.

Hydrates will dissociate or release free gas upon a decrease of pressure, increase of temperature, or combinations thereof. Premature dissociation around the wellbore must be avoided during the drilling process to minimize wellbore instability and well control issues resulting from changes in the mechanical and physical properties of the sediments when hydrates dissociate.

In addition, the hydrates dissociation into gas and fresh water will create a gas-cut mud with a lower mud density. This causes associated changes in mud rheology that reduce hole cleaning capacity, which may cause wellbore instability and potential hole collapse or a pack off and stuck pipe.

There is an enormous amount of information available in the public domain as to the characterization, composition and the location of known deposits of methane hydrates. However, the know-how to drill, complete and produce hydrates in commercial quantities is just beginning to be developed and has received little attention from the oil and gas industry.

The issues are applicable to drilling hydrates on land as well as offshore. Methane hydrates drilling-related challenges include:

- Narrow margins between pore pressure and fracture gradient in ocean surface sediments and within the hydrate reservoir;
- Surface hole instability;
- Subsidence caused by hydrate production;
- Manage temperatures and pressures within the wellbore during drilling to limit hydrate dissociation in the reservoir beyond the wellbore;
- Avoid pressure fluctuations (e.g., swabbing, surging, and ballooning) on the hydrate reservoir common to conventional drilling methods;
- At-balance installation of liners, screens and completions.

These drilling-related challenges indicate a requirement for technologies that provide more precise wellbore pressure management along with well construction and fluids programs that reduce stress to the fragile hydrate reservoir and at-balance completion.

Several relatively new but proven technologies developed for oil and gas drilling may have unique application to drilling methane hydrates.

In cases where methane hydrate drilling with conventional tools, well construction and fluids programs pose formidable barriers, tools and technology developed for underbalanced drilling (UBO), managed pressure drilling, drilling with casing, expandable tubulars, drill-in-liners, and perhaps dual-flow drill pipe, as well as slim and insulated marine risers and other emerging technologies, may significantly contribute to overcoming many of the hydrate dissociation challenges that occur in the reservoir prior to completing the production wellbore.

Sooner or later, the industry will have to learn how to drill for commercial quantities of methane hydrates.

METHANE HYDRATES

Over the past three decades, expeditions into polar regions and deepwater around the globe have consistently reported the presence of methane hydrates. The magnitude of this previously unknown global storehouse of methane is truly staggering and has raised serious inquiries into the possibility of using methane hydrates as a source of energy.

In the US, for example, about 900 Tcf of natural gas has been produced to date. An estimated "remaining recoverable with conventional technology" is 1,400 Tcf. The estimated amount of "in place" methane hydrates is 2,000 Tcf.

DRILLING CHALLENGES

Onshore, the challenges include wellbore instability that may be aggravated by conventional drilling practices, fluctuating bottom-hole pressure, risk of hydrate dissociation beyond the wellbore, and narrow margins in shallow, soft reservoir media.

For offshore, the challenges are the same as on land but are further aggravated by water depth, temperature, potentially strong currents, and seabed subsidence.

MANAGED PRESSURE DRILLING

When one considers the drilling-related challenges of methane hydrates drilling and has a grasp of the definition of MPD, it becomes more or less obvious that MPD may have a unique application. The IADC Underbalanced Operations Committee defined MPD as the following:

MPD is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.

TECHNICAL NOTES

MPD employs a collection of tools and techniques that may mitigate the risks and costs associated with drilling wells that have narrow downhole environmental limits by proactively managing the annular hydraulic pressure profile.

MPD may include control of back pressure, fluid density, fluid rheology, annular fluid level, circulating friction, and hole geometry, or combinations thereof.

MPD may allow faster corrective action to deal with observed pressure variations. The ability to dynamically control annular pressures facilitates drilling of what might otherwise be economically unattainable prospects.

MPD techniques may be used to avoid formation influx. Any flow incidental to the operation will be safely contained using an appropriate process.

OTHER TECHNOLOGIES

Drilling the Top Hole in Deep Water. In deepwater environments, hydrates have been observed between the mudline to around 4,500 ft below. A "riserless top hole drilling package," a method of dual gradient riserless drilling, may be applicable to batch drill and establish subsea locations with wellhead and casing. Such a system incorporates a subsea rotating control device and subsea choke that enables mud returns to be pressurized with pipe rotation.

A subsea pump returns annulus fluids to the floating rig via a mud returns riser or flowline. Such a system is a "riserless" closed loop circulation system and offers precise wellbore pressure management in the top hole by adjusting the surface mud pump rate; applying backpressure to the annulus at the seafloor; and adjusting subsea mud return pumping rate.

Underbalanced Drilling. Well-proven tools and technology for UBD appear to be key in improving drilling technology for methane hydrates, particularly in the practice of MPD. UBD is applicable to fixed rigs with surface BOP and floating rigs with subsea or surface BOPs.

The essence of MPD is drilling with a closed and pressurized mud returns system. Such a system enables the maintenance of a defined bottom-hole pressure at the reservoir. This could be a key element in limiting hydrate dissociation due to pressure reduction.

Such a system also permits drilling ahead while circulating out kicks and greatly enhances the ability to drill and make jointed pipe connections with a more constant bottom-hole pressure, while controlling any influx that may be incidental to the operation.

Real-time pressure and temperature monitoring and hydraulic flow modeling developed for UBD and MPD could be particularly useful to a hydrates drilling program.

Drilling with Casing. Synergistic to MPD and UBD is one-trip casing drilling technology that may address the requirement to avoid pulsating the fragile and frozen wellbore unnecessarily. Robust casing could be one-trip set and cemented to a sufficient depth to minimize the risk of seafloor collapse from the thermal, pressure or chemical quasi-mining process of producing the methane hydrates over time. Drilling with casing may also enable drilling with a less expensive floating rig because of reduced weight of casing.

Dual-Flow Drill Pipe. Heat transfer from drilling fluid to annulus returns indicates this type of drill string is worth considering. Returns are directed into one-half of the dual-flow drill pipe near the BHA and a specialized swivel maintains separation of drilling fluid and returns at the rig floor.

Low Exothermic Cement. Such casing cement may be required to reduce the risk of the exothermic reaction of the curing process dissociating the near-shoe methane hydrates. However, this may not be an issue if the hydrates can cool and restabilize before production.

Slim and Insulated Marine Riser. Deep sea currents and the need to insulate the riser (especially in temperate waters) indicate slim riser deepwater drilling with a surface BOP may be applicable technology.

The increased velocity of returns (compared to a conventional marine riser) will allow the returns chilled by drilling into hydrates less time for heat transfer to warm the returns, thus reducing dissociation within the riser itself. Further, it is believed a 13 ⅜-in. marine riser may be less adversely affected by underwater currents.

Drilling with a chilled mud system to maintain bottom hole temperature (BHT) below 11°C should be sufficient to avoid any dissociation of the hydrate and, thus, associated gas in the return riser. Deepwater drilling with a surface BOP will likely require a subsea isolation valve in case of a drive-off incident.

Other tools developed for the practice of UBD and MPD that may be applicable to methane hydrates drilling are:

- Downhole Deployment Valve (within-casing isolation valve for bit trips, avoidance of pipe light) Wireline retrievable drillstring check valve (movable to be nearer the next jointed pipe connection);
- Nitrogen production unit (enables one of several variations of dual-gradient, e.g., gas lift of cuttings);
- Continuous circulation system (maintains circulation during pipe connections).

The relatively new and emerging technologies briefly described above may have unique application to hydrate drilling and reservoir evaluation. Whereas, there are a number of unknowns about the technologies suggested to drill hydrates, now is the time for the drilling industry to begin discussions on how to adapt current technology to drill commercial quantities of methane hydrates. If nothing else, the discussion would assist in a more accurate technology gap analysis.

When first exposed to new and perhaps somewhat revolutionary ideas, human nature often causes us to first look for reasons why it won't work. Given the size of the prize, it may be wise to approach methane hydrates drilling by giving equal or more time to how to make available technology work.

ABOUT THIS ARTICLE

This article is based upon SPE/IADC 91560 "MPD-Uniquely Applicable to Methane Hydrate Drilling" presented at the 2004 SPE/IADC Underbalanced Technology Conference and Exhibition by ***Don Hannegan****, PE, and* ***Richard J Todd, Weatherford International; David M Pritchard, Successful Energy Practices LLC;*** *and* ***Brian Jonasson, Integrated Ocean Drilling Program, Texas A&M University****.*