



# Prospects of Horizontal Well Drilling in Marine Gas Hydrate Reservoir

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**Abstract.** Natural gas hydrate is a new energy source that is expected to replace fossil fuels. With the further research of marine hydrates production test, natural gas hydrates have shown great application prospects. The horizontal well mining hydrates has become the key to improve the gas production, but currently there is no mature experience in the horizontal well operation of the seabed hydrate layer. In this paper, we review the drilling tools used in conventional horizontal well and the cases of seabed shallow horizontal well, as well as related techniques for inhibiting hydrates decomposition or further generation during drilling. Possible limitation in each guiding tool for horizontal well in hydrate layers are discussed. Then based on the existing research, the development direction of horizontal well operation in marine hydrate layer is prospected. Whilst there are few cases on drilling horizontal well in marine gas hydrates, the breakthroughs will depend on the research of new drilling steering tool and drilling program, as well as further study on the mechanical properties of reservoirs.

**Keywords:** Gas hydrate · Horizontal well · Shallow layer · Hydrate production · Steering tool

## 1 Introduction

Natural gas hydrates are widely distributed in the continental permafrost zone, island slopes, active and passive continental uplifts, polar continental shelves, and deep-water environments of the ocean and some inland lakes [1]. It is estimated that the organic carbon content of global hydrate is twice the total content of other fossil energy sources. More than 98% of the natural gas hydrate resources in the world are distributed on the continental shelf offshore [2].

There are mainly several ways to extract natural gas hydrates: depressurization [3–5], thermal stimulation [6–8], CO<sub>2</sub>-CH<sub>4</sub> replacement [9], chemical inhibitor injection [10, 11] and solid fluidization extraction method [12, 13]. At present, the more effective method for natural gas hydrates in the shallow seabed is the depressurization method.

Japan [14] and China [15] have also adopted the depressurization method to conduct large-scale offshore methane gas hydrate developing tests in recent years. Due to the characteristics of shallow sediments, weakly cemented, unstable, and non-caprocks in the marine gas hydrate reservoirs, the “vertical well” pattern has been adopted in the production test of gas hydrates in the sea area. But the results showed that the gas production rate was lower than the acceptable standard of commercial gas production.

In the traditional oil and gas production process, horizontal wells and multi-branch wells have effectively expanded the contact range between the wellbore and the reservoir [16]. At the same time, compared with vertical wells, horizontal wells only need a smaller production pressure and are less likely to cause sand production. In addition, drilling horizontal wells with long horizontal sections can optimize well pattern to reduce the impact of foundation settlement on the wellhead due to hydrate development. Scholars have performed lots of numerical simulations and laboratory tests on natural gas hydrate production from horizontal wells [17–19], shown that horizontal wells perform better in terms of gas production and ultimate recovery. Therefore, horizontal well operation is an important method to improve the economic efficiency of marine gas hydrate production.

However, due to the special geological characteristics of the submarine shallow gas hydrate reservoir, traditional horizontal well drilling methods have been greatly restricted. In this paper, the related research progress and technical difficulties of horizontal well drilling will be reviewed, in view of the special marine geological environment of shallow seabed gas hydrates. Then the related countermeasures be improved for tackling key problem, to providing reference for horizontal well mining research of shallow hydrate in the seabed.

## 2 Horizontal Well Drilling Technology

### 2.1 Conventional Horizontal Well Drilling Technology

With the continuous improved requirements of cost reduction and efficiency in drilling development, traditional screw motors have the disadvantages of slow mechanical drilling speed, large friction torque, weak horizontal well extension ability, and difficult to control the well trajectory. The use of rotary steering technology (RST) in directional well drilling become more popular [20]. As a widely-applied technique, RST has shown its superiority in drilling rate improvement, reservoir discovery and formation protection. Rotary steering drilling technology was originally used for long-distance horizontal well drilling of shale gas, due to its outstanding economic benefits [21]. Now, RST is gradually used to tap the potential of old oil fields. The RST can expose more reservoirs, increase productivity and deal with complex formations. It is mainly used for precision drilling of horizontal wells, extended reach wells, multi-branch wells, highly deviated wells, and three-dimensional multi-target wells.

Drilling direction is mostly influenced by the direction of a drill bit and the side force applied on this drill bit. The RST guiding devices used in conventional oil and gas production can be divided into two types: push-the-bit and point-the-bit [22]. Push-the-bit rotary steering system (RSS) mainly generate pushing force on the well wall by three hydraulic sliders, and changes the drilling direction by the combined force of the reaction force of the well wall. Point-the-bit RSS uses an internal eccentric ring group to

drive the drill bit to generate eccentric force. Push-the-bit RSS have a relatively weaker tilt angle in the Schlumberger rotary guidance products. But due to its early market entry and good overall application, it is still in large-scale use. Point-the-bit RSS could avoid the interaction between the tool and the wellbore, weaken the dependency of the well wall. The quality of the well wall is better, and the risk of potential jamming is further reduced.

The second horizontal well technology is sidetrack drilling. Sidetrack drilling technology can drill up to 50–100 m of production flow path from the wellbore to the reservoir. Coiled tubing ultra-short radius radial drilling came about in the 20th century [23]. Compared to the traditional sidetrack drilling (the projectile perforation), coil tubing radial drilling can reduce operation cost and increase the drainage area of reservoir and then improve the individual well productivity greatly. It can be used in both old wells and new wells, and is especially suitable for the productivity improvement of old oilfields and development of offshore marginal field and small fields.

The process of drilling a radial horizontal well involves two steps: the first step is making a window on the casing with a specific tool, and the second step is to use a self-propelled jet bit to pull a high-pressure hose through the window of the casing to enter a horizontal well with a smaller diameter in the formation. The downhole tools involved in this drilling technology mainly include self-propelled jet drill bits, high-pressure hoses, reducing joints, coiled tubing, diverters, anchors, etc. Fix the anchor and the diverter at the “window” position of the vertical well, lower the jet bit connected to the coiled tubing to the anchor position, and use the diverter to guide the jet bit into the formation. By the reaction force of the nozzle and the thrust of the coiled tubing, the jet bit is advanced in the horizontal direction. It is a new drilling technology and has already been applied successfully and shown a huge potential.

## 2.2 Shallow Horizontal Well Drilling

At present, there are few reports on the drilling of horizontal wells in shallow seabed, and all these methods are in the experimental stage. In 2004, Japan organized the world's first natural gas hydrate horizontal well in the Nankai-Trough [24]. The horizontal well was kicked off at 20 m below the mudline and successfully landed horizontally when drilling to 472 m, the horizontal section was 100 m long. It took a total of 8.5 days. During the drilling process, the angle was kept building up using BHI's mud motor with a bent housing adjusted at 1.5 to 1.8°, the well hit into hydrate zone at 225 m, and continue drilling 317 m in the hydrate reservoir. It is reported that the horizontal well did not experience high friction and high torque during drilling. For various reasons, in the completed horizontal well, only a very short casing pipe (175.39 m) was set, and the completion process was not continued.

It is worth noting that a BHI's mud motor was used in the horizontal well drilling process of the seabed hydrate layer. Due to low compaction of the formation, the slope of the RSS in seabed formations is unstable. The mud motor drilling tool has a higher slope-defining ability in shallow formations than the RSS drilling tool. But with the improvement of drilling technology in recent years, the slope of the RSS is gradually

guaranteed by turning into closed circuit or transforming drilling fluid in advance, adopting lower displacement and higher weight-on-bit, and adding flexible short joints to the drilling tool combination, etc.

In 2011, Norwegian scholars proposed a new suction anchor type well foundation concept that presses the wellhead into the formation through the pressure difference between the inside and outside of the cavity [25, 26]. Compared with the conventional wellhead, the new wellhead avoids direct contact between cement and the formation, reduces cement leakage, and the casing can be pre-tilted to a certain angle inside the wellhead. Using this suction anchor well foundation, in 2016, a horizontal well was successfully drilled in shallow formations with a water depth of 400 m and a depth of 250 m below the mudline in the Barents Sea of Norway. However, this field is a reservoir of gas. The mechanical properties of the reservoir are quite different from those of the marine gas hydrate. This method of drilling shallow horizontal wells has certain reference value for drilling horizontal wells in hydrate reservoirs.

### 2.3 Methane Hydrate Drilling Technology

The hydrates in seabed are extremely sensitive to temperature and pressure. When the temperature of the local layer increases and the pressure decreases, the hydrates in the formation will decompose. When drilling of gas hydrate formations, the damage caused by the drilling tools to the formations resulted in the release of stresses in the well wall and near the bottom of the reservoir [27–29]. Under the temperature difference and pressure difference, drilling fluid inevitably invades the formation for heat and mass transfer, resulting in hydrate decomposition in the reservoir, which may cause serious well control problems.

In recent years, with the development of drilling equipment, a gas-liquid separation device is often used to separate the gas and liquid phases in the drilling pipeline to prevent the formation of natural gas hydrates, when designing deep-water drilling schemes in the ocean [30]. In 2013, the world's first marine hydrate trial production in the Nankai Trough, a gas separator and an electronic submersible pump were installed in the drilling pipeline to separate the gas and liquid phases in the pipeline to prevent the formation of hydrate.

## 3 Drilling-Related Challenge

### 3.1 The Ability to Control Dogleg Severity

In the marine environment, the special temperature and pressure characteristics determine the possible zone for marine hydrates. As shown in Fig. 1, below the depth where the green curve and red curve intersect, CH<sub>4</sub> hydrate is stable and if gas exists below this depth, such as free gas in pores. It can be known that the gas hydrate stable zone is mainly located in the shallow seafloor. Therefore, it is inferred that the exploitation of horizontal wells in marine hydrates requires the completion of horizontal well operations in the shallow seafloor.

Due to the shallowness of the natural gas hydrate reservoir in the seabed, the building depth of the wellbore is insufficient. For horizontal wells designed in shallow areas, for

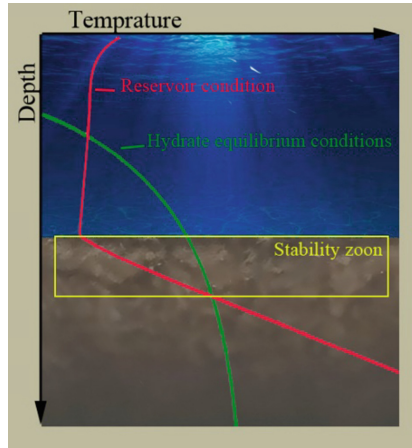


Fig. 1. Stability conditions of gas hydrate

example, building angle from 0 to 90° inclination over a vertical of 250 m, required an average of dogleg severity (DLS) of 9/30 m. To keep the DLS requirement low, it was envisaged to start building as early as possible, which incentivized the engineering team to investigate options for shortening the conductor. That is, the vertical depth from the kick point to the horizontal landing point is insufficient. Due to the limitation of vertical depth, this puts forward higher requirements for the high-angle build ability of the guide tool. The existing steering tools are usually applied to deep oil and gas reservoirs, and are not special steering tools designed for shallow horizontal drilling. Therefore, the applicability of guide tool in shallow drilling is limited, which is quite different from the drilling tool of traditional horizontal wells in oil reservoirs.

For the problem of the high DLS of shallow horizontal wells, the restriction of the horizontal well rotary steering drilling can be solved by increasing the steering tool's build rate or optimizing the kick point. Although the drilling method of the coiled tubing radius radial horizontal well is not restricted by the DLS rate, it has high requirements on the quality of the wellbore, and it needs to operate under the condition of casing, which still has great construction difficulties.

### 3.2 Reservoir Mechanical Properties are Unstable

During the exploration of gas hydrate reservoirs, marine gas hydrates are mainly found in the Cenozoic strata in the shallow surface of the ocean floor, which relied on appropriate pressure and geothermal gradients. The overburden layer of hydrates zone is mainly composed of thin silts interbedded with fine clay, and the mechanical strength of the formation is unstable [31]. The presence of the hydrate will significantly increase the mechanical strength of the sedimentary layer, because the hydrate in formation play the part of cement in the sandstone. If the large amount of hydrate were decomposed, the stability of the surrounding rock of the well will decrease, resulting in the wellbore collapse. When the reservoir is opened, the wellbore is easily to shrinks and collapses, increasing the friction when entering the conductor. At the same time, due to the existence

of a long seawater section, it is difficult to control the downhole mechanics during casing inserted, which may cause the casing slip into wrong place, fail to complete the well normally, further to limit the adaptability of sidetrack drilling horizontal well.

In deep water, due to poor cementation of the upper overburden layer, the shallow fracture pressure is small, the drilling mud density window between the fracture pressure and the formation pressure is narrow, and the bearing capacity is low. Compared with conventional oil and gas reservoirs, natural gas hydrate formations are softer, drilling fluid density windows are narrower, and lost circulation are more likely to occur.

The shallow weak cementation mechanical properties also increase the difficulty of horizontal well drilling. Because the sedimentary layer is relatively soft and lacks stable support [32], the push-type rotary guidance system cannot be used at this level. Although the directional rotary steering system avoids the dependence on the borehole wall and reduces the interaction between the tool and the wellbore, it is still difficult for the drill bit to obtain a stable support force during directional drilling, and cannot fully meet the requirements of trajectory control. In addition, the high rigidity of the traditional drilling, and the vibration during drilling is obvious, which further weakens the bearing capacity of the formation and results in an increase in the offset of the wellbore.

### 3.3 Wellhead Stability

The surface conductor, marine riser and under water wellhead are initial channels of deep-water drilling. Their stabilities are related to the whole progress of offshore drilling. Main factor weaken stability of wellhead are focused on the vibration of riser in water, lateral ocean current load, jetting depth of surface conductor [33]. The subsea wellhead is in a complicated stress state, and the risk of wellhead instability is existing. Meanwhile, the subsea silt-clay shallow foundation has low bearing capacity and high compressibility [34].

Decomposition of hydrate would further weaken the stability of wellhead. In the drilling process, interactions between hot fluid in drilling annulus space and hydrates can destabilize hydrates near the wellbore. But the decomposition rate is relatively low [27]. The reason is that the pressure in the hydrate layer is higher and the temperature increasing is limited by the relatively low thermal conductivity of the hydrate layer. But, in the development process, continuous hydrate dissociation can weaken the strength of hydrate formation, which may damage to equipment on seabed [35].

In submarine gas hydrate sediments, the pore spaces are partially occupied by the solid phase of gas hydrates. The gas hydrates in the pore can act as a cementation (bonding) agent between soil particles. The reduction in hydrostatic pressure of the hydrate reservoir, or increases in the temperature of the reservoir leads to the dissociation of the gas hydrates. The solid phase of the gas hydrates is lost and the hydrates change into the fluid phase, i.e., water and gas. When this released fluid pressure is trapped inside an area of low permeability, the effective stress, which is one of the factors of describing strength of the sediments, should be reduced and slope failure can be triggered, resulting in submarine landslides. The submarine landslides may lead to even worse situation, for example, cutting submarine cables, wellhead rollover and well-site subsidence. However, we do not have enough knowledge about the behaviors of sediments caused by dissociation of hydrates in the ground [36].

### 3.4 Wellbore Instability

Hydrate dissociation in the formation can lead to problems with wellbore stability, and impact adversely on the efficiency and eventually, safety of drilling operation. In the drilling with a riser, gas from the hydrates enters the returns annulus, and cannot be isolated from the rig floor. Under these conditions, the drilling fluid can become highly gasified (referred to as gas-cut mud) which lowers the mud density [37]. Further dissociation of the hydrates is promoted by this decrease of the drilling fluid pressure and a viscous cycle is established. When gas hydrates dissociate, the mechanical and physical properties of the sediments adjacent to the wellbore will change. The change in material properties associated with the dissociation includes in permeability, reduction in modulus and loss of the cementation provided by the gas hydrates.

However, the temperature of annulus mud has a more hazard in hydrate decomposition. At present, the safety and stability of the borehole wall during the drilling process has been studied by many researchers [37–41]. Most of the researchers only focused on numerical simulation, in which have shown that the temperature of drilling fluid is the main factor of hydrate decomposition. In addition, the gasification leads to lowering of the mud density, reduction of the drilling fluid pressure which may cause wellbore instability.

A further side-effect of the drilling fluid pressure reduction is reduction of its mechanical support to the wellbore that could lead to hole enlargement and possible wellbore collapse. Meanwhile, changes in mud rheological properties will impact hole cleaning capacity and combined with changes in the formation strength and pore pressure within the formation may lead to hole enlargement and wellbore collapse.

### 3.5 High Probability of Geological Hazards

When drilling in marine gas hydrate reservoir, the formation temperature and pressure changed by the drilling process will lead to hydrate decomposition [28]. The gas produced by the decomposition cannot be dissipated in the pores in time, lead to excessive pore pressure surrounding the well. The effective bearing capacity reducing in the sedimentary layer could easily cause natural disasters such as seabed landslides and subsidence.

In addition to the effects of hydrate decomposition, shallow seabed strata also have a series of risk problems such as unstable seabed, low bearing capacity, free gas, over pressure water, and potential seafloor instability [42]. Although the methods for identification and mitigation of these hazards are available, they are not yet mature.

## 4 Prospects for Horizontal Drilling Technology in Submarine Hydrate Layer

Based on the drilling challenge in hydrate layer, there are some main factors to solve challenges. 1) build horizontal well in shallow layer; 2) hold the borehole pressure; 3) optimize the drilling fluid. In the building horizontal well in shallow layer, hydro jet radial drilling and wellhead steering technology provide practicable method for finishing shallow horizontal well. Borehole pressure is the main factor to maintain the safety in drilling.



Holding the borehole pressure have significant effect on preventing the decomposition of hydrates, maintaining the wellbore stability, mitigating the geological hazards. The last factor is optimizing the drilling fluid. In this part, related technology will be reviewed.

#### 4.1 Hydro Jet Radial Drilling

Most marine gas hydrate are wrapped in weakly cemented sand. For horizontal wells which do not require high extension distances, coiled tubing rotary jet drilling is also a feasible method. After the completion of the vertical well, the “window opening” tool was run for “window opening” and radical drilling. Horizontal drilling was performed by coiled tubing radial horizontal drilling technology, as shown in Fig. 2.

Aiming at the difficult of casing completion, some scholars have proposed casing drilling method and drill pipe drilling method. Casing drilling method refers to the simultaneous drilling and casing operation, which can reduce the effect of pumping pressure on the well wall, to maintain the stability of surrounding gas hydrate. When drilling with casing drilling method, the cuttings will be ground into fine particles. Under the effect of liquid column pressure, the particles will be squeezed into the borehole wall and the borehole surface will be covered with a certain thickness of mud cake. This phenomenon is called smear effect. This can effectively improve the leakage of drilling fluid and strengthen the stability of the wellbore. Drill pipe drilling method refers to use of large diameter drill pipes for drilling. When drilling to a predetermined depth, the drill pipe, drilling tools and drill bits in the well cannot be raised, and the drill pipe remains in the well as a casing.

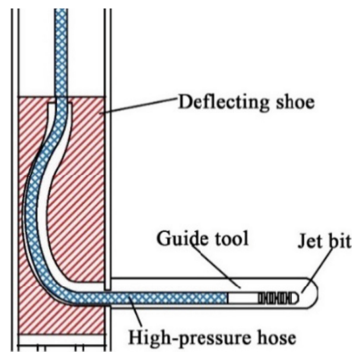


Fig. 2. Coiled tubing radial horizontal drilling technology

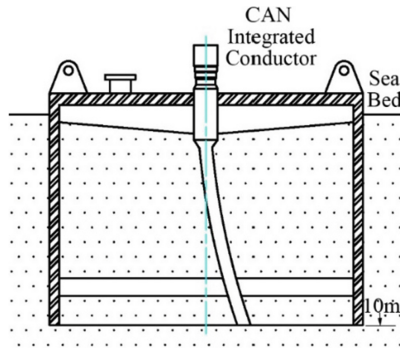
The jet fluid is required to have a dual function as a power medium for horizontal drilling and as a support for the fracturing fluid. That is, while the jet is using for drilling, the jet liquid is pressed into the hydrate reservoir and can form a support in the reservoir to provide a channel for natural gas to migrate to the well.

The disadvantage of sidetrack radial drilling method is the insufficient extension ability of the horizontal section. The extension ability from the wellbore to the reservoir is currently only 50–100 m. For long-distance horizontal well operations, mechanical drill bits are still required to cooperate with rotary steering drilling technology.



## 4.2 Wellhead Steering Technology

Conventional submarine conductor uses jet downpipe technology, and the length of the conductor is generally 60–80 m. The length of the conductor greatly shortens the vertical depth from the kick point to the horizontal landing point, which makes it difficult to drill horizontal wells in the submarine gas hydrate layer and limits the usage of rotary steering tools in shallow hydrate formations.



**Fig. 3.** CAN with integrated slender conductor

To shorten the conductor, a conductor anchor node (CAN) was designed [26]. The appearance of CAN provides a feasible idea for solving the problem of insufficient vertical depth. The CAN is like an inverted bucket. During installation, the CAN will penetrate seabed by suction pressure. Due to the large wellhead size of CAN, the wellhead stability is much higher than that of normal conductor. Compared with conventional wellheads, CAN wellheads have a shallower installation depth (10–11 m), shorter installation time (<20 h), higher stability (longitudinal bearing capacity of more than 400t), and can be reused.

Large-scale wellhead piles are more stable than traditional conductor cementing, which greatly reduces wellhead instability caused by lateral forces, and provides more stable support for the drilling of horizontal wells in the shallow layer. As shown in Fig. 3, the conductor can be pre-tilted at a certain angle inside the pile body, instead of bearing the load, which could rise the kick point. Compared with the conventional wellhead conductor structure, using CAN integrated conductor is more suitable for horizontal well drilling of subsea gas hydrate.

Based on strengthening wellhead stability and rising the kick point, the rotary steering technology currently used for drilling horizontal shale wells can be applied to horizontal well drilling in shallow seabed. However, there are still problems such as difficulty in controlling the inclined well section, unstable inclination, and insufficient extension ability. Based on the existing technology, it is necessary to realize the diversification of rotary steering technology, and optimize the combination of drilling tool according to the characteristics of natural gas hydrate reservoirs, further increase the slope rate during actual drilling, and reduce drilling risks.

### 4.3 Surface Conductor Jet Drilling Technology

Surface conductor jetting drilling is a deep-water drilling technique developed to cope with loose deep-water seabed soil and prevent shallow geological disaster [43, 44]. Surface conductor is tripped in place by jetting mode, utilizing water-jet and the gravity of conductor string. When drilling to the preplanned depth, make the conductor string static, utilize the adhesion friction force of the seabed surface soil to make the conductor firm. The model of jet drilling is shown in Fig. 4. During the jetting process, the diameter of the jetted cavity should be controlled to be smaller than the conductor OD (outer diameter) to ensure the casing can penetrate into the clay by the BHA (bottom hole assembly) and its self-weight which can provide enough bearing capacity [45].

Jet pipe drilling technology is a crucial technology in deep-water drilling, it has advantages as follow: Being free of cementing, saving time, boosting drilling speed, simplifying drilling procedure and reducing cost [46].



Fig. 4. The model of jet drilling

### 4.4 Dynamic Kill Drilling Technology

Dissociation of methane gas from its frozen lattice-like structure within the near-wellbore and until the mud and cuttings have been returned to the rig's surface separation equipment must be avoided for well control reasons [47]. Such as: 1) Blowout because of sudden gas hydrate dissociation, 2) Slope failure risk due to sudden gas hydrate dissociation, 3) Wellbore stability problems and wellbore collapse risks due to the loose sediments after gas hydrate dissociation. During the drilling process, the temperature of reservoir will rise with the fluid circulation, even though the temperature of drilling mud should be limited in the well head. If dissociation of free gas from frozen methane hydrate crystalline structures is to be avoided, the drilling process must incorporate a means of preventing near wellbore and annulus pressure drops.

On the other hand, during the deep-water drilling, there are few risers or intermediate casings for the interval of shallow formation [48]. Therefore, since the column pressure of building fluid cannot balance the formation pressure, once encountering the shallow gas or flow, the fluid with high pressure will expend to the low-pressure area in a high speed, and then form into the shallow kick, resulting a series of problems.

Hence the well control is very critical before running the intermediate casing and installing the blowout preventer. Nevertheless, wellhead blowout preventers (BOPs) have not been installed in surface drilling process, so the conventional methods cannot be used to circulate out the kick. The dynamic kill drilling (DKD) is a new method to realize effective well control [49]. The DKD is to mix the seawater into the weighted drilling fluid to form a series of drilling fluid with different density based on a certain percentage, and then to pump the weighted drilling fluid into the wellbore with high speed [50, 51], shown as in Fig. 5.

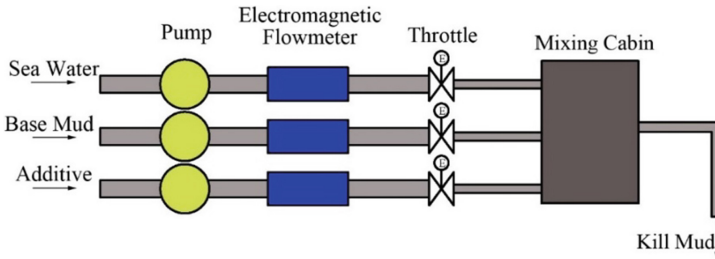


Fig. 5. DKD main devices

Dynamic kill drilling is a key technology that has the potential to solve the problem in deep-water surface drilling [52]. In this method, the mixing proportion is determined by the annular behavior through the annular pressure measurement while drilling (APWD) system, ensuring the mixture density can be maintained in the “narrow drilling window” between formation’s pore pressure and fracture pressure [53].

#### 4.5 Optimize the Drilling Fluid

It has been concluded that by cooling drilling fluid and decrease the circulation rate, the influence of drilling through gas-hydrate-bearing sediments on petroleum operations can be minimized [54]. High mud weight to increase the hydrostatic pressure may also be used to stabilize gas hydrates but caution must be exercised in its implementation as excessively high mud weight can fracture the formation and lead to lost circulation, particularly in unconsolidated marine sediments. Therefore, reducing the temperature of drilling fluid and making the pressure slightly higher than the fracture pressure of the formation are beneficial to maintaining the stability of the hydrate. Surface mud coolers may be required to chill the drilling fluid, this to avoid dissociation from an increase in temperature within the methane hydrate reservoir.

In addition, some special inhibitors or oil-based drilling fluids can also stabilize natural gas hydrates. This matter depends on the rational drilling fluids system. The drilling fluid should be able to effectively inhibit gas-hydrate aggregations in the drilling pipe and blowout preventer. In addition, for drilling in gas hydrate bearing sediments, the use of inhibitor for hydrate decomposition should be considered carefully because they prevent hydrate dissociation in the formation, but can also cause the aggregation in the borehole, if their concentration is too high.

## 5 Concluding Remarks

Marine gas hydrates are usually stored in shallow argillaceous siltstones in the form of cementation or pore filling, and their mechanical properties change due to their decomposition during mining. With the progress of mining, the mechanical properties of the hydrate reservoir gradually deteriorate, and the supporting force for the upper overburden gradually decreases, causing the formation to settle. Improper control will cause collapse and even geological disasters. Although the mining scheme of horizontal wells for the exploitation of marine natural gas hydrates will slow down the risks of formation subsidence and well collapse, further research is needed to ensure the reliability of horizontal wells and the safety of production. Study the effects of hydrate decomposition on foundation settlement under different reservoir conditions, and reduce the risk of wellbore stability and wellbore integrity during the entire life cycle.

Wellbore pressure is related to the stability of natural gas hydrates in the wellbore. Pressure controlled drilling technology can be used to solve the complex conditions that occur during the drilling process. When drilling in a submarine gas hydrate formation, a well drilling plan is designed to control the temperature and pressure during the drilling process. According to the actual formation characteristics, the temperature and pressure during the drilling process are jointly controlled to ensure the hydrate in the formation. It will not be decomposed in a large amount and hydrates will not be formed in the drilling pipeline, ensuring the safety of drilling in the gas hydrate layer.

Deep water hydrate reservoirs have low overburden pressure and high degree of under compaction. Compared with traditional oil and gas reservoirs, the requirements for the strength of drilling tools are greatly reduced. This means that the combination of drill bit and rotary steering tool is not necessary for the horizontal well operation of subsea hydrate reservoirs, and the jet pressure requirements for hydraulic drilling are also greatly reduced. With the gradual expansion of hydrate mining, it is necessary to design some new lightweight drilling tools to adapt to the efficient development and utilization of natural gas hydrate resources.

**Funding.** National Natural Science Foundation of China (No. 51890914).

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