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Managed Pressure Drilling (MPD) – Applications of an Innovative Drilling Method

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Abstract

This paper describes the new drilling riser-less concept for deepwater operations that will remove some of the well control challenges and limitations currently experienced when handling kicks and deep formation gas flow into a well being drilled. There are analyzed the differences between the conventional drilling system and the MPD system, the benefits and the disadvantages of the MPD method. Also the paper presents a case study were the MPD system was used successfully.

Introduction

In the actual context of the expansion of the drilling and exploration industry, one of the main objectives is to drill deeper and deeper with minimum costs and in a safe manner. Many of the offshore drilling operations encounter different problems as: lost circulation, blowouts, dangerous gas flow which can migrate to the surface, stuck pipes.

The solution to all this problems is to apply the managed pressure drilling, a method that offers to the operator the possibility to totally control the annular pressure while drilling. This ability is making possible the compliance of drilling projects that are not possible to accomplish through conventional drilling methods.

The MPD technique is based and developed on the Underbalanced Drilling technique. The equipment used on the two methods is almost identical, but actually the two methods are different. The underbalanced drilling method is drilling under conditions where the pressure being exerted inside the wellbore from the drilling fluids is less than the pressure of the water, oil or gas in the formation being drilled. And the MPD method is an adapting drilling process used to precisely control the annular pressure through the wellbore.

Conventional Drilling

During normal drilling operations from a semisubmersible the mud is pumped down the hole through drill string and the returns are taken back on the surface through flow line, in an open system. (fig. 1).

An open circulation system is one in which the drilling fluid flows out of the wellhead through surface piping open to atmospheric pressure. In many drilling operations the formation pore pressure represents the lower boundary for the bottom hole pressure (BHP) and the minimum that has to be maintained to avoid influx, kicks, and subsequent losses. The minimum pressure boundary for well control may be dictated by wellbore stability pressure not pore pressure.

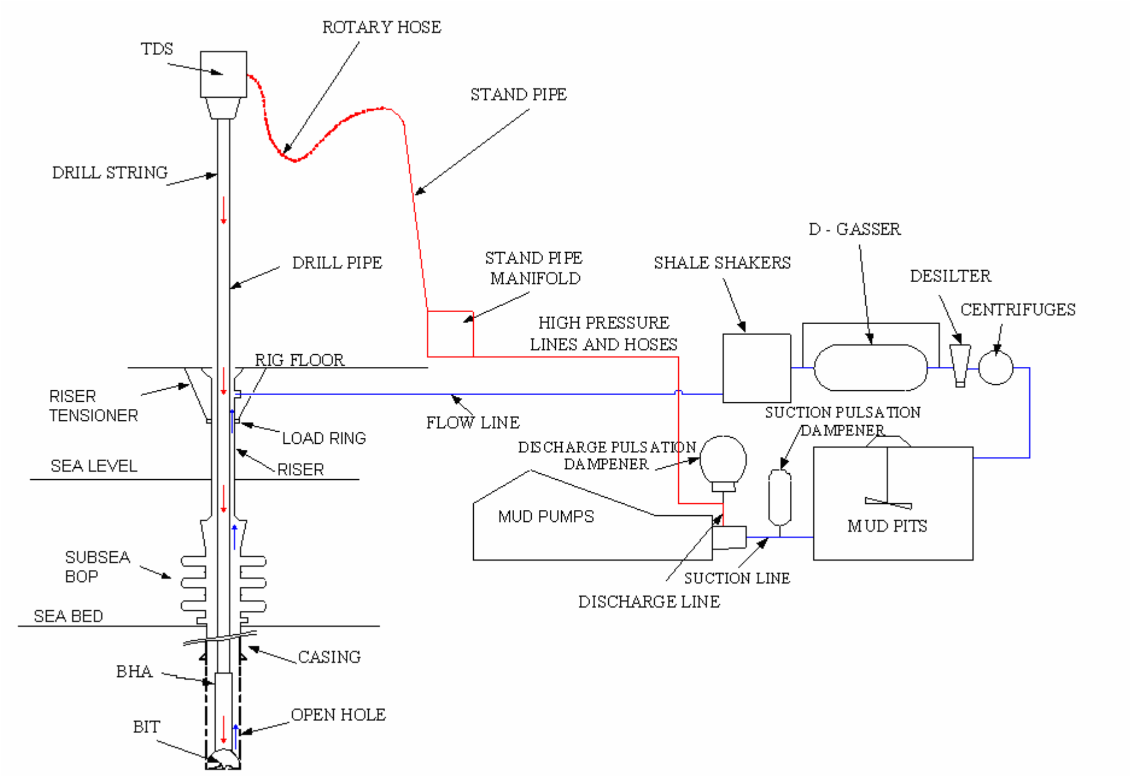

Fig. 1. Circulating system during normal drilling operations

Wellbore stability tends to be a more complex pressure phenomenon than pore pressure because it is a function of the magnitude and direction of the maximum horizontal stress, well orientation relative to well inclination, drilling fluid rheology and in particular its density, pore pressure, rock porosity and permeability, as well as pump rate, rotary speed, and rate of penetration.

Generally, the wellbore stability pressure is greater than the pore pressure. The difference can be as small as 0.2 - 0.5 ppg equivalent mud weight (EMW) or as much as 2.5 - 3.0 ppg.

The risk of wellbore instability is heightened by the open system itself. Over time a circulating drilling fluid can charge an annular volume of rock near the borehole with equivalent circulating density (ECD) pressure. The depth of charging is limited only by the permeability and porosity of the rock itself and the degree to which the drilling fluid plugs the porosity channels at the borehole wall. When circulation stops the charged volume relaxes and the BHP reverts to BHP static which will be lower than the pressure of the charged rock. This cycle of charging and relaxation is sometimes referred to as ballooning and occurs every time the mud pumps are started and stopped. It stresses the rock, induces wellbore fatigue, and ultimately leads to tensile failure.

In an open system under conventional drilling conditions there is no way to maintain the ECD constant.

Managed Pressure Drilling (MPD)

Managed pressure drilling is a drilling technology that accurately controls annular pressure while drilling and completing wells.

The purpose of MPD is to manage the annular hydraulic pressure profile to fit within the allowed pressure window as well as to handle a well control situation within this window with assistance from advanced model tools and automated control systems.

The pressure window is the pressure between the pore pressure and formation fracturing pressure. MPD may be accomplished by many means including combinations of backpressure, variable fluid density, fluid rheology, circulating friction, hole geometry and using an active device to manipulate the mud gradient and dynamic pressure.

To successfully apply the MPD system on a well, the annulus must be sealed off to prevent the mud from flowing out and to maintain surface pressure. A Rotating Control Device (Head) (RCD), a technology taken from Under Balanced Drilling, is used to seal the well bore. On a fixed platform or land well this can be achieved by installing the RCD just above the BOP (fig 2).

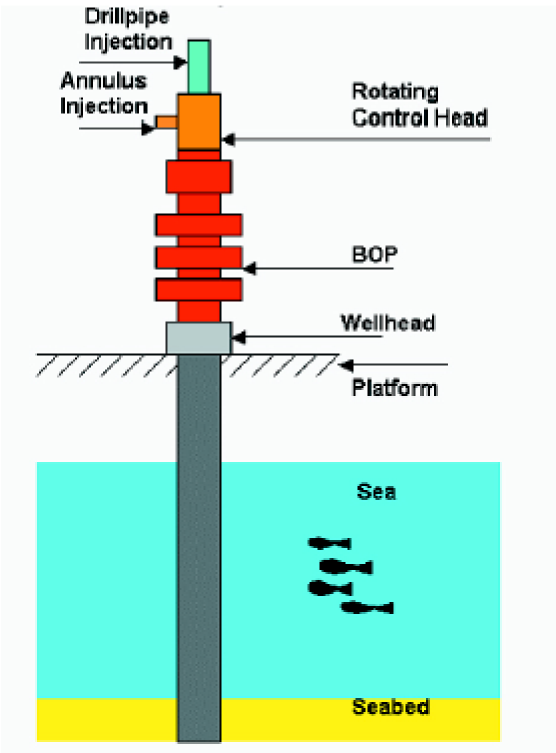

Fig. 2. Platform well setup for MPD

On the drill string side, float valves are installed to prevent the influx of hydrocarbons through the drill string when making connections. The challenge to install the RCD for Subsea drilling operations is the difference in BOP setup. In subsea operations the BOP stack is located at the seabed, connected to the subsea wellhead and a riser string allow for mud returns. By installing the RCD on top of the riser slip joint, it is possible to convert the conventional drilling to a MPD system (fig. 3).

The MPD system is an advanced form of primary well control, employing a closed, pressurizable fluid system that allows grater and more precise control of the wellbore pressure profile than mud weight and mud pump rate adjustments alone.

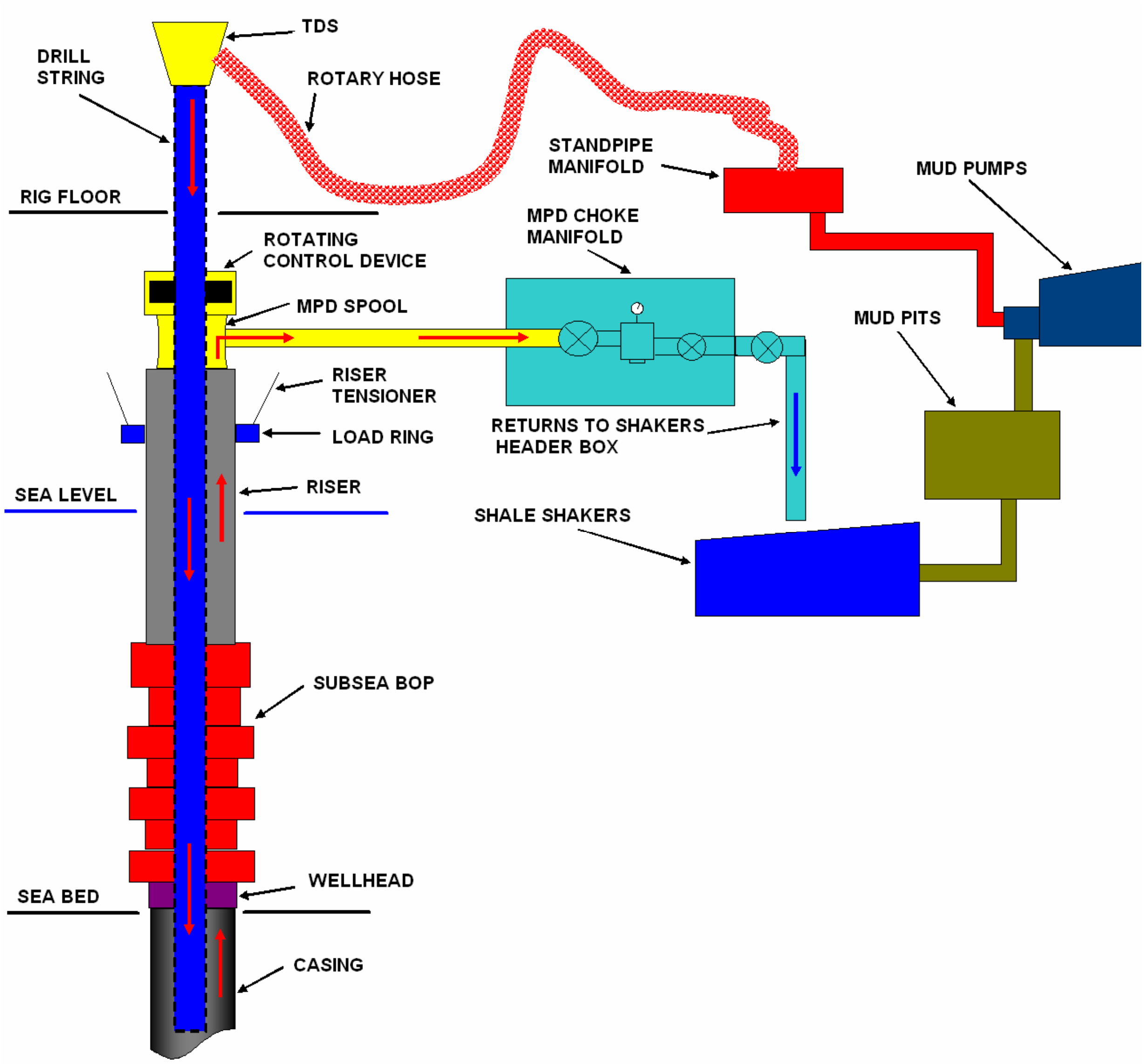

Fig. 3. Subsea well setup for MPD

As opposed to a conventional open-to-atmosphere return system, MPD enables the well to be viewed as a pressure vessel, where the pressure is controlled by the micro-flux system integrated in the rig equipment. (fig. 4).

The components of an MPD system are:

1 – Rotating Control Device.

2 – Compact Integrated Manifold:

- Two drilling chokes;
- Mass flow meter;
- Electronics and choke controls;
- Data acquisition system.

3 – Remote Control and Display.

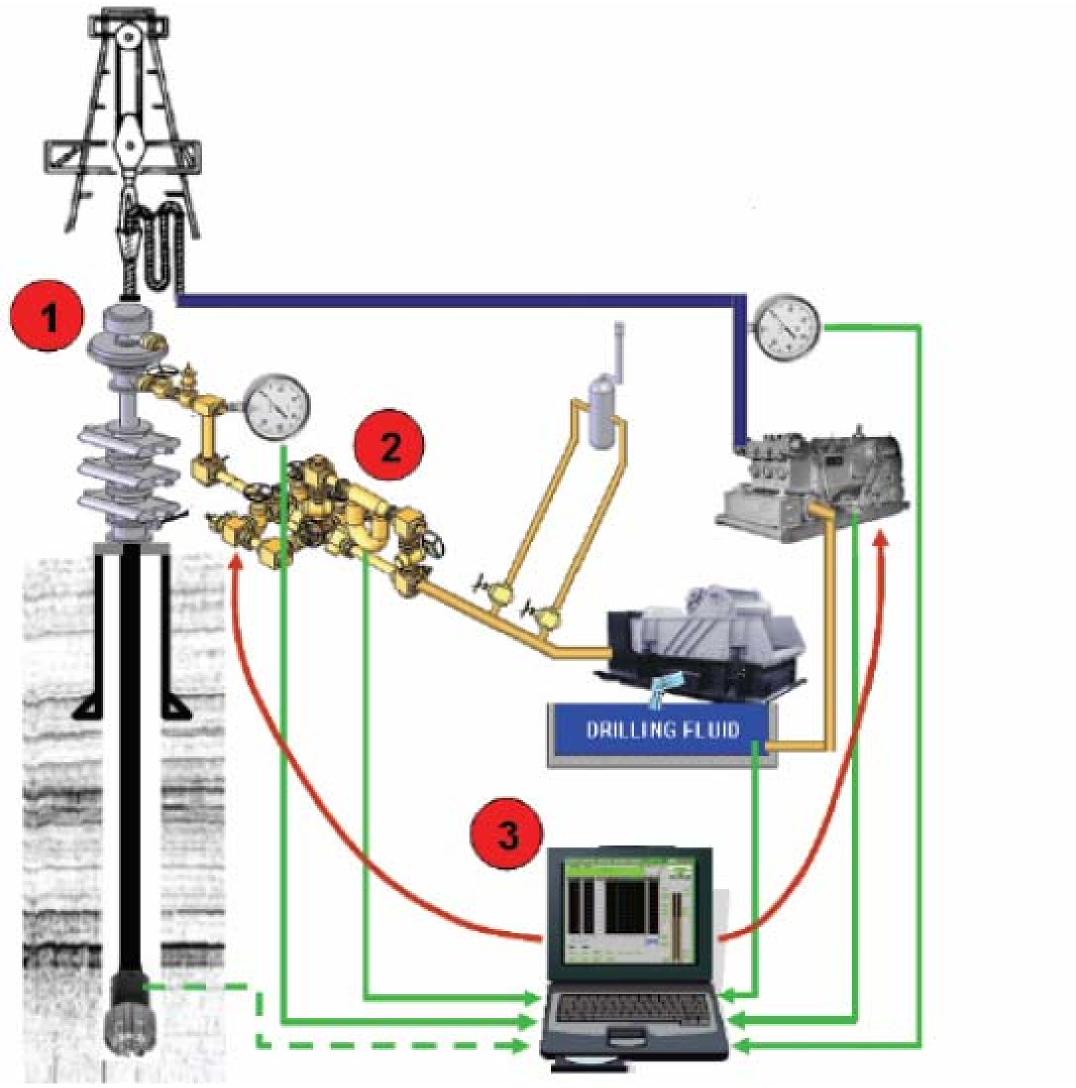

Fig. 4. Micro-flux control system

Benefits

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

Also using the MPD technique, the MPD operator can detect any influx from the formation and can apply back pressure immediately, keeping the bottom hole pressure at a constant level.

Upon detecting an influx, annular pressure can quickly be added to a safe margin below the minimum fracture gradient. This can be done either while drilling at full circulation rate or when ramping down the pump to zero by adding the same incremental pressure to pressures used during the connection pump ramp down sequences.

The MPD processes employ a collection of tools and techniques which may mitigate the risks and costs associated with drilling wells that have narrow downhole environment limits, by proactively managing the annular hydraulic pressure profile.

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. Comparing with the conventional drilling system, were usually is need of a 10 to 15 bbls to detect the influx, with the new MPD system is need just for 1 to 2 bbls to detect the influx, and the back pressure is applied automatically.

MPD allow adjusting of the equivalent mud weight with minimum interactions to drilling ahead.

In case of any worn, RCD seal elements are easily replaced on drill pipe. With the last technology available the RCD have a back up seal assembly also.

Disadvantages

The BOP test tool could not pass the ID of the RCD and BOP testing has to be done in advance.

Drag forces from the RCD seal elements made string weight interpretations more complex especially during fishing operations.

Training required for drilling crew to work with new equipment.

Modifications required on rig equipment.

Rigging up operations of the MPD equipment will take more time than in normal rigging up of the conventional drilling equipment.

Case Study

The MPD method it was applied with success to few high pressure high temperature wells situated offshore Libya. Before applying the MPD method, the wells were drilled with the conventional drilling method, but the operator decided to suspend the wells, due to different well control problems. They were drilling in the non-consolidated sand formation and actually the drilling was impossible due to alternate of losses and gains to/from formation. It was performed an evaluation of the formation gradient (fig. 5) and it was established that it is impossible to control the wellbore pressure only by controlling the mud weight and the pump flow.

After the wells were suspended, they have reopened some of them using a new drilling rig, which was equipped with the MPD system. This time the wells were successfully drilled to the desired depth. This was possible due to the use of the MPD system, which allowed keeping an accurate control of the annular pressure and a quicker answer to any influx or loses from/in to formation.

Conclusions

The MPD technique generally rely on a closed-loop circulation system, which lead to a reduced risk of lost returns, improved kick tolerance, drilling with annular control at all times.

Using the managed pressure drilling method many challenges and issues concerning well control can be avoided. As we continue to explore in grater water depths the MPD method offers many advantages in comparison with the conventional drilling method. That is why the MPD method is called the "the drilling of the future".

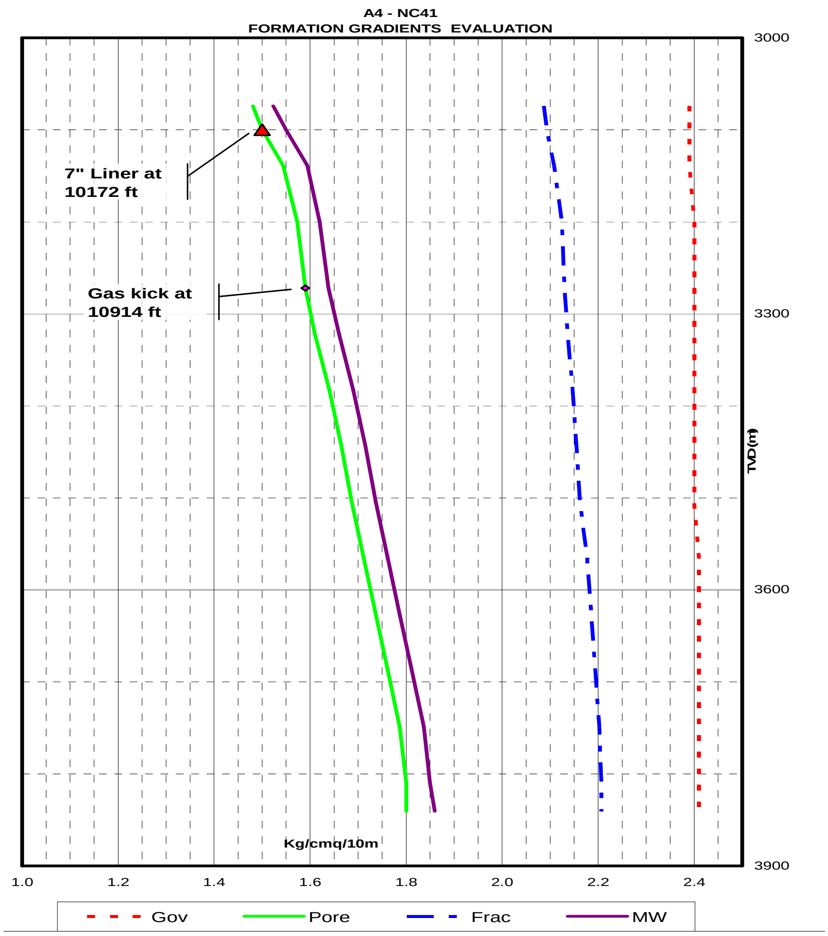

Fig. 5. Formation Gradient Evaluation

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Forajul cu presiune controlată – Aplicații ale unei metode noi de foraj

Rezumat

În lucrare se prezintă un concept nou de foraj fără riser pentru operațiunile de mare adâncime, concept ce înlătură unele din problemele şi limitările legate de controlul găurii de sondă, probleme ce sunt întâmpinate în prezent, în cazul unei erupții sau unei migrări de gaze la suprafață, în timpul forajului. Sunt analizate diferențele dintre forajul convențional şi forajul cu presiune controlată, dar şi beneficiile şi dezavantajele sistemului de foraj cu presiune controlată. Deasemenea în lucrare este prezentat un studiu de caz unde sistemul de foraj cu presiune controlată a fost aplicat cu succes .