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Closed System Drilling

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Abstract

In actual conditions,when the hydrocarbons necessary is so big, the drilling industry is put face to face with new and impressive challenges, because it have to realise wells in very difficult environment like depth, water depth, long distance from shore,a.s.o.
Classical way of well control only by mud density is difficult and expansive to apply in these hardwork conditions. A complete control of the well pressures it's necessary, not only to the bottom but also in some parts of the circle space and on the open well. This impose the completion of the circulatory system with working in and out of the well devices for a complet control of the well.

Key words: *rotating clos device, parasite casing string,flow choke, dual gradient.*

Introduction

Regarding drilling as an industrial and universal activity it may be discussed about just from the beginning of the XX- th century, starting with the onset and establishment of Rotary method. If good results in the field have all appeared, it was mainly due to operators' enthusiasm, courage and intuition. A large-scale activity took place after the `50, when the research began to make the difference between a hazard based activity and one based on programmed science.

The records, predictable from now on, were impressive and it may be mentioned: drilling in deep sea waters at 4000m, small diameter and continuous coring drilling, over 10000 m ERD wells, horizontal drilling in a few meters thick layers with similar size curvature radius, underbalance drilling. All of these were based on an increasingly improved technology and it can be mentioned: raiser casing, drilling platforms positioning systems, M&LWD, polycrystalline diamond compact (PDC) bits, sealed friction bearing drilling bits, helicoidally engines, composite material casing, expandable diameter casing. Generally, these spectacular achievements have arisen in response to the various challenges posed by the heavy conditions encountered in the around the world oil fields.

Classical Drilling

Oil drilling industry has now a rich arsenal of techniques and technologies - established by solving punctual problems - that may cover almost the whole range of challenges that will not wait, and we keep in mind now that the main objective of the drilling industry - sustained growth of hydrocarbons reserves - is strongly conditioned by environmental problems.

It is believed that the main objective may be done by carrying out two goals:

1. Bring in the circuit of some deep, deep sea water, far away from shores and harsh conditions production zones.

2. Opening of productive layers without effecting hydrocarbons flow, both new and depleted old deposits, that resumes operation for a more complete exploitation.

Just to get a better idea of how the drilling industry will be able to respond to these challenges, we should take a look at the possibilities of applying the Rotary method, by far the most used in XX century and probably the one that will be used at a grater scale in the XXI century. Under the drilling rotation-hydraulic method, the displaced rock by drill bit action on the bottom hole is removed from the bottom hole and evacuated to the surface by the direct movement of drilling fluid. In addition to this feature, the fluid also has – through replacing the rock in the created well hole interval and exercising pressure on the whole depth of that range – the role to diminish more or less the effects of removing of that mass of rock from the earth. The Reflection of this fluid feature is done by the correlation between the well pressure and surrounding rock at a certain depth.

$$p_p \le p_n \le p_f \qquad (1)$$

where:

p_n is the hydrostatic pressure of fluid from the well at a certain depth;

$$p_n = h\rho_n g \qquad (1a)$$

p_p – the pressure of fluids from the well walls rock pores, at a certain depth;

$$p_p = h\Gamma_p \qquad (1b)$$

p_f – the rock fracturing pressure, at a certain depth;

$$p_f = h\Gamma_f \qquad (1c)$$

the meaning of terms is:

h – the current depth;
ρ_n – the drilling fluid density;
g – gravitational acceleration;
$\Gamma_{p/f}$ – the pressure rate from pores, respectively fracturing for the rocks of the wall.

During drilling a producing interval, p_n may vary in a wide range by adjusting the fluid density, in order to meet two objectives:

- achieve the highest drilling speed level;
- ensure well's wall stability until is consolidated with a casing.

In order to achieve the first objective mud density need to be reduced without changing the left term of correlation (1) sign, and for the second objective mud density has to be increased up to rocks density.

In the classical drilling where the well hole is open, keeping the correlation (1) validity is possible only by altering the drilling fluid density, feature with a limited range of variation from a technical perspective. Furthermore , provided the well pressure varies proportionally relative to depth, not the same thing may be said regarding pores or fracturing pressure variation, that has nonlinear variation with depth, with jumps sometimes quite high, or when the values of the two pressures are becoming equal, sometimes it is almost impossible to keep the correlation (1) in practice.

Because of this we can reach in both situations where you cannot keep the sign of the left term of correlation (1) and we are forced to circulate the drilling fluid out of the well through blowout preventer, and the situation where we cannot keep the right term conditions of the correlation (1), therefore being forced to stop work in order to obturate loss areas. Sometimes the density variation range is very narrow – under 50 Kg/m.c. We have to do with so called "drilling on a rope" , when it is extremely difficult keeping the situation within the correlation (1) limits , bringing the operator in a position to act conjecturally. When the correlation (1) conditions cannot meet, the only alternative is an intermediate casing to ensure the conditions for continuing the drilling operation.

Circulation System Completion

Regarding the hydrocarbon reserves sustained growth objective, we agree to simplify, that the first goal is to increase the drilling length required for wells, and the second goal is to open the productive layer without blocking (skin phenomenon).

Increasing wells' length beyond current limits require, from a technical point of view, to reduce the number of intermediate casing strings, in order to ensure a reasonable diameter for the production string . This can be done by finding ways to extend the scope of validity of the correlation (1) for longer well intervals. An important role it can play drilling fluid as type and properties all together with circulating system. Also, longer casing strings may be cased-off in steps, using expandable diameter pipes, or finding procedures to continue work even when the correlation (1) conditions are no longer valid (blind circulation drilling or underbalanced drilling).

Opening productive layer without inducing blockage involves the use of fluids with 0 fluid-loss, fluids with virtually instantaneous clogging capacity, and application of underbalance drilling methods, accomplish well- layer communication routes without causing overpressure waves.

It may be easily noted that both goals are based on operators' capability to control the bottom pressure and in certain areas of the annulus. Under the conditions of classic drilling is if not impossible, at least very hard to respond to this challenges and certainly is very expensive.

Drilling operator needs a circulations system that allows him to control pressure in certain areas of well. Circulating system changes have been and are used for underbalanced drilling methods. Following we will refer to what we call "Closed system drilling**".** This drilling method aims to avoid some of the difficulties encountered in underbalanced drilling implementation, such as highly polluting gaseous fluids control.

Using this method of drilling it, both goals may be reached. Furthermore, by the application of this method a lot of environmental problems may be solved; more precisely, all the fluids leaving the well are strictly controlled; they cannot get free in the environment.

This system should allow well's drilling with a full pressure control in as many well's areas as possible, particularly in the annulus. Technically speaking, to ensure a constant pressure on the well's bottom and certain points of the annulus, regardless of the operation in progress: drilling, run in drill pipe, running. In order to successfully implement this system, the drilling rig must be supplemented with surface and down-hole specific equipment. Following are some of these equipments, shown in picture no.1.

- Rotary sealing device (not necessary rotary preventer).This should seal on the kelly or on the last pipe in case a topdriver is used- and to withstand several tens of bar pressure. Rotating sealing device is equipped with two branches, one for connection to pressure pump for annulus, and the other for by-pass connection;
- flow nozzle, for well exit pressure control;

- pressure pump, for filling the annulus;
- gas-liquid separator, for separating the gas circulated by the operator in order to reduce the fluid density in the annulus or from crossed layers;
- flame initiator;
- liquid-liquid separator for separating circulated lighter fluids or from the crossed layers;
- parasite casing string or concentric, for circulating light fluids in order to reduce drilling fluids density on a certain length of the annulus.

Possible Applications

In order to successfully use the additional equipment shown in figure 1, this should be completed with performant software for deterring the pressure drops in the annulus or portion thereof, related to any change in flow rate, fluid density, and detritus production frequency.

The operator may meet different goals based on well exploration program data and on those obtained during the realization of it, from tests and measurements. Some of these objectives are:

- keeping a constant pressure on the well's bottom during various phases of drilling: circulating, drilling, circulation stop, run in drill pipe, circulation resumption, running;

- blind circulation crossing and heavily fractured areas (vugular) mudcap protection;

- drilling longer depth intervals using dual gradient method, using parasite or concentric casing strings.

We will present for the last goal a theoretical example, based on Figure 2 data. In this figure it is presented a construction program for a difficult well, with H= 5400m depth, pores and fracture fluid pressure gradients that were the basis of this program. Due to narrow window shaped by the two gradients along the well, a large number of casing strings were imposed, namely seven.

In order to drill a well on the same structure, for exploring the conditions from 7-8000 m, we will reconsider the current program in order to reduce the number of casing strings. to ensure the possibility of casing an production string with a diameter large enough for 7-8000m depth. The fairly complex program for 5400m well will be used as a pretext on which to show a theoretical possibility of casing program simplification through rigorous monitoring pressures in certain well areas.

Considering that there is compatibility between the scheduled types of fluids and the rocks crossed by intervals, we will try to solve the problem by controlling the pressure in the annulus, both through required density changes and using the completed circulating system according to figure 1.

1. Large diameter surface casing , 30 in. at 250m;
2. Large diameter technical casing string, 24 in. at 1500m.

Large diameters have been provided for this casing string in order to mount inside a parasite casing string throughout its length, well protected against drilling string action or a concentric casing string running in. The goal of this additional equipment is to circulate some lighter fluid in order to reduce drilling fluid density from the inside of the casing string up to the surface, for bottom hole and annulus pressure reduction up to the casing string shoe.

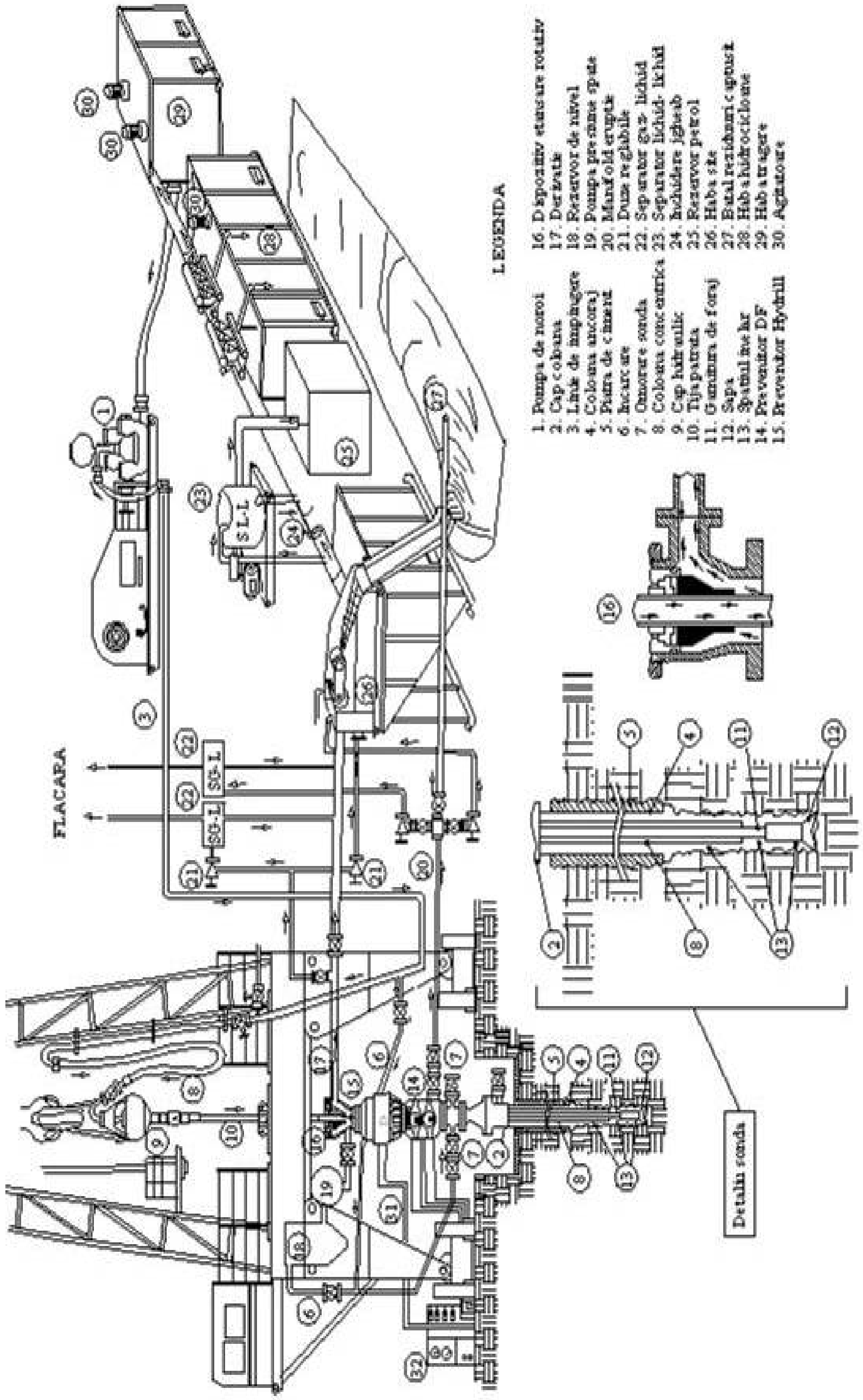

Fig. 1. The overall scheme of devices used to achieve the closed system drilling

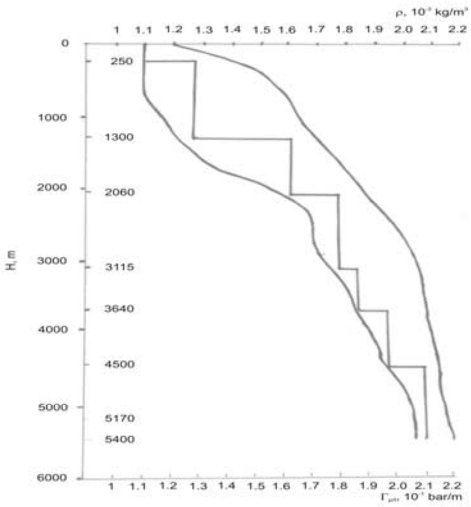

Fig. 2. Construction program proposed to be modified.

The fluid density used for this casing string interval drilling is 1300 Kg/m^3.

Due to heavy weight, the casing type of this string is set according to the used rig.

3. Technical casing II, at 3650m;

The first variant: $18^{1/4}$ in. Casing string. Start drilling with a 1600 Kg/m^3 density fluid, used up to 2050m depth. From this level the fluid density is increased to 2060 Kg/m^3, but well circulation is complemented by a light fluid circulation through the concentric casing strings, in order to reduce the fluid density from the technical casing string I to 1360 Kg/m^3.

Recommended densities are approximated due to the fact that during circulation or drilling the bottom hole pressure (or in other areas of the ring annulus – the one from 3100m), is given by the equivalent density, that depends on the flow rate and the fluid detritus loading.

The second variant (20in. liner at 2050m) + ($181^{/4}$ in. expandable liner at 3650m).

Up to 2050m depth the drilling fluid density is 1600 Kg/m^3, and after the liner casing and cementing an 1800-1850 Kg/m^3 fluid density is used, up to an 3650m depth where the next liner is cased. Intermediate casing string III, $13^{3/8}$ in. liner 4500m deep + $10^{5/8}$ in. liner 5400m deep. A 2050 Kg/m^3 fluid density will be used. This schedule theoretically allows well extension over the next 2000m, using liner diameters from $7^{5/8}$ in to $5^{1/2}$ in.

Fluids density for each interval is considered equivalent densities, established with the help of software based on concrete conditions for each part.

Conclusions

1. Changing the circulation system in order to increase well pressure control possibilities will increase oil and gas well drilling efficiency.
2. Using an improved well pressure monitoring system, oil drilling industry will look toward a new expansion.

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Foraj în sistem inchis

Rezumat

In conditiile actuale, cand necesarul de hidrocarburi este asa mare, industria de foraj este confruntata cu noi si impresionante provocari, in sensul ca trebuie sa realizeze sondele in conditii foarte dificile, ca adancime, adancime de apa, distanta mare de tarm s.a.
Modul obisnuit de control al sondei numai prin reglarea densitatii fluidului este greoi si scump in aceste conditii grele de lucru. Se impune un control mai complet al presiunilor in sonda, nu numai la talpa, ci si in anumite portiuni ale spatiului inelar si la gura sondei. Acest lucru necesita completarea sistemului de circulatie cu dispozitive care sa lucreze in sonda si la suprafata in vederea exercitarii unui control complet al sondei.