DESIGN OF DRILLING MUD FOR DEEPWATER HP/HT WELLS

Panbarasan[1], Karthikeshwaran Ramasamy[2]
[1]Assistant Professor, [2]Assistant Professor
[1]Department of Petroleum Engineering, AMET University, Chennai, India
[2]Department of Petroleum Engineering, VISTAS, Chennai, India

Abstract : One-third of the deepwater wells in the world have the characteristics of HP/HT. An integrated analysis of engineering and geological environments for deepwater HP/HT wells is studied and the problems encountered during drilling are taken into account. Based on that, a solution for drilling in deepwater HP/HT wells ought to set off with drilling mud. Mud engineers have designed a new water based mud system compatible with deepwater HP/HT wells on the basis of a conventional drilling mud.

***IndexTerms* –** Drilling mud, HP/HT, gas hydrates, deepwater, polyacrylamides.

I. Introduction

Drilling a well in offshore where depth of water is more than 650ft is referred as Deepwater drilling. Various problems are encountered during the deepwater drilling and are as
i) Storms and hurricanes
ii) Loop and eddy currents cause vortex induced vibrations & motion to drill strings
iii) "Thief zones" of significantly lower pressure which cause lost circulation.
iv) Gas hydrate formation
In order to overcome the above problems, it requires modifications in existing rigs and equipment and drilling fluids.
The deepwater reservoirs are deeply buried with a low seabed temperature but the same reservoir has HP/HT characteristics in the lower part of the well interval. Due to the lower temperature of the seawater environment causes an increase of drilling mud viscosity in the riser and deteriorates the rheology which leads to increase of Equivalent circulating density (ECD) that in turn results in fracturing of reservoir (Lost Circulation). HP/HT reservoir conditions will also result in a constrict drilling-mud window. The drilling mud designed has to be HT-resistant and must prevent overflow and wellbore instability, as well as increase the safe drilling window[1-9].

II. Disputes bumped in use of Drilling muds

While drilling at a depth range of 5000 – 10000 ft, the following challenges are encountered: The deepwater operated water depth is between 5000-10000 ft and the highest temperature window is
i) Temperature variation
ii) Narrow fracture pressure
iii) Gas hydrates formation in mudline

If the water interval is few feets to few kilometres in deepwater wells generally forms a 35 – 40°F low-temperature interval from the seafloor to 1650ft below sea level. The low-temperature environment eases up the change of flow properties of drilling mud in the riser, which tends to gelling effect thus results in increasing density and viscosity. This leads to the higher friction in the well bore flow and raises the chance of formation leakage at the casing shoe. While designing a drill mud for a conventional deepwater wells care is taken on the low-temperature resistance without considering the effect of higher temperature at deeper depth. Still, HT will induce degradation and cross-linkage of certain drilling-mud additives, damaging the antipollution characteristics and the water solubility of the additive.

During the drilling operations in HP/HT deepwater along reservoir formation, the gelling effect occurs at low temperatures and the drilling mud deterioration takes place which reduces the cutting carrying capacity of mud as the gel strength reduces. Hence, deepwater HP/HT drilling can run into more technical disputes than conventional deepwater drilling.

Certain widely used drilling mud systems could not fully satisfy the necessity of the compound/complex geological environment of deepwater HP/HT well. Therefore, it became necessary to design a unique drilling mud system for the deepwater HP/HT geological environment.

III. Synthesis of Deepwater HP/HT Drilling fluid system

In general, low-molecular weight polymer is used extensively to control rheology attributes in offshore drilling thus prevents the drilling mud thickening at low temperature. Formation of hydrate will also affect the rheological properties of drilling mud and cementing quality, which will influence operational safety. Presently, thermodynamic inhibitors are widely employed to mitigate the formation of hydrate while drilling deepwater wells. Types and quantity of inhibitors can be obtained by simulation studies through laboratory experiments or software. To keep the wellbore clean, flow rates of mud pumps and booster pumps has to be increased. In addition, hydraulic software such as HYDPRO, CleanMax are used to perform real-time simulation and calculation throughout the operation to monitor variations of ECD.

3.1 Synthesis method

Right from the beginning of the drilling process, considering the various technical challenges occurred by deepwater HP/HT drilling muds and with the available conventional deepwater drilling mud system as a cornerstone, a HT-resistance filtrate reducer was introduced. In the meantime, the hydrate inhibition ability of the entire system was studied. By this way, synthesis of a drilling-mud system which is suitable for deepwater HP/HT wells could be attained.

3.1.1 Low temperature resistance system

While using a water-based mud, at the cold seabed temperatures twinned with high pressures can results in the formation of gas hydrates. Hydrates are formed as water molecules and low-molecular weight gas. Gas hydrates are white-ice like crystalline cage structure formed around the gas and make way for the risk of blocking the choke and kill lines at the blowout preventers. The following are the conditions required for gas hydrate formation:

i) Reduced temperature
ii) Elevated pressure
iii) Presence of gas
iv) Presence of water

This can be prevented by maintaining the appropriate salinity level in the WBF inhibits hydrate formation.

Current measures to inhibit gas hydrates starts with Semi-inhibition. Semi-inhibition is the process which inhibits the formation of gas hydrates during the drilling operation. Inorganic salt (any salt that doesn't contain carbon) and ethane-1,2-diol are the most common hydrate inhibitors. In addition to that, Kalium salts can significantly enhance the temperature-resistance capacity of polymer. Halite and Methanoic acid are extensively employed as hydrate inhibitors. For extreme conditions, propane-1,2,3-triol, polyglyceryl-3 oleate, ethylene glycol is used to suppress the hydrate-formation temperature.

The critical temperature for hydrate generation is 55°F at 2200 psi and 60°F at 2900 psi, reaching the requirement of semi-inhibition. Various studies show that this can be prevented by using 5% NaCl and 10% KCOOH together.

3.1.2 High temperature resistance system

The mud used in deepwater HP/HT wells should have the following properties

i) Stabilized rheology
ii) Low filtration loss

and it is also available readily at cheap cost.

The polymers have the property of low filtration loss. They are polyacrylates and polyacrylamides which can be withstand upto 400°F.

IV. RESULTS AND DISCUSSION

i) A drilling fluid with pressure coefficient at 2.10 at 360°F which is compatible for deepwater HP/HT wells. Its rheology is steady at low temperature, so the probability of hydrate formation is less. It also has good sag stability, firm antipollution attributes and reservoir protection capability.

ii) The optimized drilling-fluid system also enhance the formation pressure holding capacity to a certain extent.

REFERENCES

[1]. J.Abdo, M.D.Haneef, "Clay nanoparticles modified drilling fluids for drilling of deep hydrocarbon wells" Applied Clay Science, Elsevier, Volume 86, Pages 76-82.

[2]. Luigi F.Nicora, PierangeloPirovano, Nils Blomberg, Knut Tangbol, "High-Density Invert-Emulsion system with very low solids content to drill ERD and HPHT wells" Journal of Petroleum Technology, SPE, 2001.

[3]. GaoE, Estensen O, Macdonald C and Castle S, "Critical Requirements for Successful Fluid Engineering in HPHT wells; Modeling Tools, Design Procedures and Bottom Hole Pressure Management in the Field "GaoE, Estensen O, Macdonald C and Castle S, SPE 50581, 1988.

[4]. Gibson MT, Bergerot JL and Humphreys A, "Developing a greater understanding of the well hydraulics in HP/HT wells: An updated study of the wells in the Elgin/Franklin Fields". The 4th Annual Industry Forum, Aberdeen, UK, 1996.

[5]. Houwen OH and Geehan T, "Rheology of Oil-Base Muds", Journal of Petroleum Technology, SPE 15416, 1986.

[6]. Pal Skalle, "Drilling Fluid Engineering", 6th Edition, ISBN – 978-87-403-1139-6

[7]. Basmadjian.D, "Mathematical modelling of Physical System", Oxford University Press, New York, 2003.

[8]. ,A.T., Jr., Chenvert, M.E., Millheim, K.K. & Young, F.S., Jr. "Applied Drilling Engineering", Bourgoyne: SPE Texbook Series, Vol.2 3rd Edition, Society of Petroleum Engineers, Richardson(1991).

[9]. Chilingarian, G.V. and Vorabutr,P, "Drilling and Drilling Fluids", Elsevier science publishers, Updated first edition (1983).