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An Experimental study of Aphron Based Drilling Fluids

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Summary

Most of us are aware of the opportunity that exists for increasing recovery factor by applying proven technologies from other parts of the globe. Although, there are a large number of technical publications that list the benefits of applying these technologies to specific reservoirs, however many of them have not been tested in the lab/field to check whether it can be customized/ tailored for Indian scenarios or not. As for the case when the lab results show positive results, transferring the technologies to the field has a high probability for success. Safety, minor cost and minor formation damage which are the basic goals of good drilling practices are not achievable when formation pressures are drawn down in mature reservoirs e.g. most of the producing fields in India. The problems associated with the pressure variances encountered in mature fields, coupled with the constraints of conventional fluid and equipment technologies to properly provide an equitable solution, have driven the need for a new approach to drilling and work-over operations within depleted reservoirs. One of the latest approaches to this dilemma is the use of the Aphron Based Drilling Fluid Technology, which is now used globally to drill through depleted reservoirs/wells. This paper discusses the application of the Aphron Based Drilling Fluid Technology, with its success stories from field, which is offering a unique opportunity to significantly improve the operational and economic aspects for continued development of marginal assets across the globe.

Introduction

Drilling the pay zone is one of the most important aspects of the drilling procedure, thus drilling mud which is suitable for drilling the rest of the formation may not be acceptable in the pay. The formation damage created by the mud is acceptable in a non productive interval, but not in the pay zone. What is needed is a mud which can control leak off without creating any formation damage. The most important aspects of a drilling mud is to minimize formation permeability damage and to prevent loss of the drilling mud filtrate and to make sure that filtrate is lost will not react with the formation to reduce permeability. Drilling in depleted reservoir, high permeability formations, and in other under pressure zones is a challenge in well completion, construction including economical viability of fields. Various methods have been developed by injecting air or inert gases into the fluids in order to reduce the equivalent density of the drilling fluids. But it is observed that these bubbles are not stable and collapse at high temperature. One of the latest approaches to this dilemma is the use of the Aphron Based Drilling Fluid Technology, which is now used globally to drill through depleted reservoirs/wells.

A laboratory study was initiated to understand the physical, chemical and rheological properties of both water and oil based Aphron drilling fluids for successful completion of wells and which is offering a unique opportunity to significantly improve the operational and economic aspects for continued development of marginal assets across the globe. Aphrons allow conventional drilling equipment to be used and are produced easily at the surface with standard mixing equipment. The Aphron based drilling fluids have recently been used as drilling fluids in order to eliminate the problems associated with depleted reservoirs and underbalanced drilling fluids. Like regular foams, Aphrons are mainly composed of a gaseous core. As unlike aerated mud Aphron drilling fluids will not corrode the drill string because nitrogen remains within the Aphron shell and the diffused oxygen is consumed by the base fluid.

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Aphron Based Drilling Fluids

Sebba's concept on Aphrons is that it is surrounded by a surfactant tri-layer, within this is a semisolid aqueous layer. The outer layer is thought to be polar hydrophilic (Figure 1)14. Good aphrons possess a strong, impermeable shell. This helps the Aphrons to survive at high pressures also. Brookey portrayed the first use of Aphrons in drilling fluids which controls the lost circulation and minimizing formation damage in low pressure formations. Initially polymeric water based Aphron drilling fluids were used for all type of formations which created a problem in clay formation and recently and thus led to the invention of non aqueous based drilling fluids5. Aphrons are surfactant-stabilized structures that resemble conventional bubbles. The polar heads of the molecules that make up the outermost surfactant layer are oriented into the aqueous drilling fluid, thus making the structure hydrophilic and dispersible in the fluid. This outermost surfactant layer also imparts an anionic charge to the structure not unlike that possessed by particles coated with dispersants or thinners. Thus, aphrons tend to have little affinity for each other or for anionic mineral surfaces[1].

Aphrons aggregate together when it is applied to high pressures and these high pressures are due to Laplace pressures which are caused due to differential pressure between the annulus and low pressure formation (Figure 2). During the well completion, if the pressure in the annulus is decreased then the aggregated aphrons will get dispersed[15].

Authors have mentioned earlier that controlling pressure variances is a key feature of the Aphron technologies. The mechanical fluid features of the system and micro-environment seal facilitate controlling pressure transmissibility from the annulus into the reservoir. Another feature of the fluid mechanics of this system is its ability to control or limit leak off of filtrate from the bulk fluid system into the reservoir as filtrate. The leak off of filtrate into the reservoir where primary permeability is low results in phase trapping and therefore compromised production. Today we employ an additional technology with the Aphron fluid to obtain synergistic benefit for mitigating phase trapping and facilitating reservoir vitalization. That is the micro-solution technology. It will aid the Aphron systems mechanical features of multiple phase flow by enhancing their separation which means a more effective creation of the micro-environment seal. The micro-solution will vitalize production from the reservoir by traveling with any filtrate leak off from the bulk Aphron system fluid into the primary permeability of the reservoir and reduce the naturally occurring capillary pressures by over 60%.

Table 1

Water based drilling fluids	Oil based drilling fluids
Fresh water	Oil or synthetic fluid
Polymer blend	Polymer blend
Surfactant	Surfactant
PH buffer	Water
Soda ash	Filtration controlling agent
Biocide	

Table showing components of both Water Based and oil Based Aphron Drilling Fluids

Both of these fluids consist of a viscosifier, Aphron generator, Aphron stabilizer and surfactant which helps in producing bubbles. The major difference between the two fluid systems is the continuous phase which is water in water-based aphron system, and oil or synthetic fluid in oil-based aphron system[6].

Measurements of Viscosity, Density and API Filtration Loss:

Viscosity and gel strength are measurements that relate to various flow properties of fluids. The study of the deformation and flow characteristics of matter is called rheology. The marsh funnel is a simple device used for routine quick measurements of fluid viscosity. It is an excellent indicator of changes in drilling fluid properties. It is observed that the low shear rate viscosity obtained for the aphron based drilling fluids from the OFITE Model 900 viscosimeter is higher than that of the conventional fluids. Rheological properties measure with rotational viscometer is commonly used to indicate solids buildups flocculation or deflocculation of solids, lifting and suspension capabilities and to calculate hydraulics of a drilling fluid. The plastic viscosity and yield point obtained for this fluid is higher when compared with the conventional fluids also. The Gel strength is a function of the inter-particle forces. An initial 10-second gel and a 10-minute gel strength measurement give an indication of the amount of gellation that will occur after circulation ceased and the mud remains static. The more the mud gels during shutdown periods, the more pump pressure will be required to initiate circulation again. Static filtration tests are used to indicate filter cake quality and filtrate volume loss for a drilling mud under static conditions. It is observed those types and quantities of solids and their physical and chemical interactions. Temperature and pressure further affect these solids and their interactions.

Table 2

Properties	Oil based drilling fluids	Water based drilling fluids
Density	900-1500	500-100
Plastic viscosity	5-10	10-15
Yield point	20-25	30-35
Gel strength	10-15/20-30	20-25/25-30
LSRV	50000+	60000+

Comparison of physical properties of typical water-based and oil-based aphron systems is presented above.

Results and Discussion

From the study, it has been shown that both the base fluids have high values of low shear rate viscosity, but viscosity of Aphron at these shear rates is low. High LSRV provides higher- superior cutting transport and suspension and lower HSRV helps in lowering stand pipe pressures and minimizes the pressure losses, ECDs, surge/swab pressure, effective hole cleaning. Increase in surfactants leads to increase in the amount of aphrons and finally result in decrease in low density. The aphrons does not affect viscosity. The physical properties depends upon the type of surfactant used and are not influenced by the type of base fluid used.

The oil and Gas industry in India is very pragmatic so when something different comes about they are very resistive to change. It takes a long time. The Aphron water base fluid was used about 8 – 10 years ago in India in carbonate reservoir for NIKO. Areas where the application of aphron drilling fluids in India is the offshore carbonate which uses mainly oil base fluids out there. Laminated sand shale sequences are another good area where the aphron fluids can be applied. The Aphron drilling fluids technology has been successfully applied in drilling all types of wells, as well as it is used for completion and work over operations. From the literature study it has been found that Aphron base technology which is used for hundred of wells worldwide have been successfully drilled through depleted reservoirs in mature oil and gas fields, high permeability formations and micro fractured rocks.

Even though this technology is used worldwide but still use of this technology for suitable formation is critical. Air and foam based systems require additional equipment like compressors to run. They are used to controll the hydrostatic head pressure. They still imbibe and phase trap tight primary permeability in carbonates. The comparable cost for one M3 of these fluids would see Aphrons being much higher. Aphron water base mud costs about the same as diesel oil base mud costs per M3. Instead of using air/ foam based drilling fluids it is recommended to use aphron based drilling fluids which doesnt either affect the cost in installing the equipments. In a lot of wells, the aphron fluid would be better for the well construction process than drilling with air of foam.

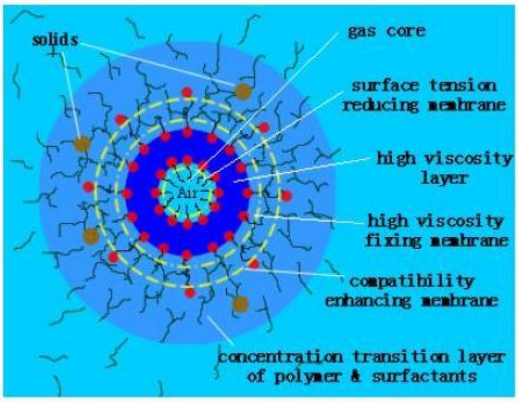

Figure 1: Schematic Diagram of Aphron Reference from paper presented in SPE international student paper contest at the SPE annual technical conference and exhibition[16]

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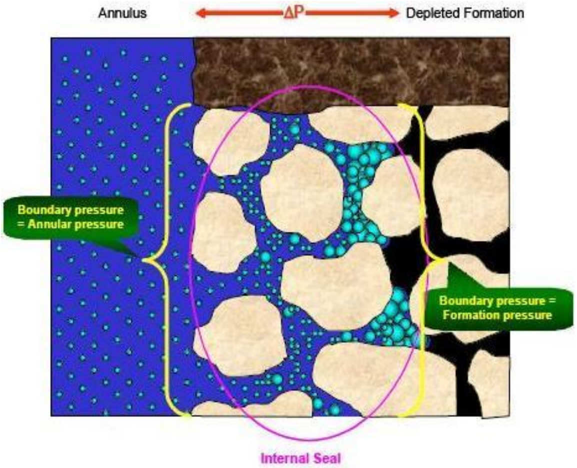

Figure 2: Aphron Bridging Mechanism Reference from paper presented in AADE 2004 Drilling Fluids Conference[6].

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