УДК 622.24

ПРИМЕНЕНИЕ ПОНИЗИТЕЛЕЙ ФИЛЬТРАЦИИ ПРИ БУРЕНИИ ГОРИЗОНТАЛЬНОЙ СКВАЖИНЫ НА НИГЕРИЙСКОМ МЕСТОРОЖДЕНИИ «Х»

–––––––

APPLICATION OF FLUID LOSS ADDITIVES TO THE DRILLING OF A HORIZONTAL WELL IN NIGERIAN OILFIELD «Х»

Амеде Гудлак
магистрант,
Кубанский государственный
технологический университет
amedegoodluck@yahoo.com

Чуквуемека Аугустин Окечукву
магистрант,
Кубанский государственный
технологический университет
engineaust@gmail.com

Ибегбуле Сандра Озиомачукву
студентка,
Кубанский государственный
технологический университет
sibegbule@yahoo.com

Филиппов Евгений Федорович
кандидат технических наук, доцент,
Кубанский государственный
технологический университет

Amede Goodluck
Undergraduate,
Kuban state technological university
amedegoodluck@yahoo.com

Chukwuemeka Augustine Okechukwu
Undergraduate,
Kuban state technological university
engineaust@gmail.com

Ibegbule Sandra Oziomachukwu
Student,
Kuban state technological university
sibegbule@yahoo.com

Filippov Evgeny Fedorovich
Candidate of technical sciences,
Associate professor,
Kuban state technological university

Аннотация. Поглощение промывочной жидкости пластом при бурении нефтегазовых скважин уже давно служит как препятствие к процессу успешного бурения и до сих пор еще является актуальной проблемой. В этой статье рассмотрены общий обзор этой проблемы и способы борьбы с ней на примере горизонтальной скважины на месторождении Нигерии.
В ходе анализа было обнаружено, что крахмальная добавка-понизитель фильтрации имеет меньшую величину водоотдачи по сравнению с целлюлозной добавкой-понизителем и поэтому является более перспективным при бурении в осложненных условиях с аномально-высокой пластовой температурой.

Ключевые слова: фильтрация, фильтрационная корка, поглощение, нефтегазовая скважина, добавка-понизитель, нефтяное месторождение, аномально-высокая пластовая температура.

Annotation. Fluid loss while drilling oil and gas wells has long served as an obstacle to successful drilling and still remains an actual problem today. This article takes an overview of this problem and various ways of tackling it with a horizontal well in a Nigerian oil field as case study.
In the course of the analysis, it was found that the starch derived fluid loss additives have a lower fluid loss value and higher viscosity values as compared to cellulosic additives and therefore is more suitable for drilling horizontal wells under complicated conditions of abnormally high temperature.

Keywords: filtration, filter cake, loss of circulation, oil and gas well, fluid loss additives (FLA), oil field, abnormal high layer temperature.

Introduction

Almost all drilling problems, to some degree, can be linked to the drilling fluid-which is like the blood of the drilling process. Be it stuck pipe, wellbore instability, kicks, production layer contamination and others. Another major and very frequent problem occurring during drilling of oil and gas wells is fluid loss, also referred to as loss of circulation, seepage or partial returns. It's almost impossible to drill a well without experiencing this problem and in fact, the issue usually is not a total avoidance of this problem, as there will always be rocks with natural caverns and fractures where part of the drilling fluid leaks off to, but rather a minimization of this fluid loss occurrence or its severity. This article seeks to take an overview of both this fluid loss problem while drilling and conventional methods of dealing with it.

Mechanism Of Fluid Loss In Drilling Oil And Gas Wells

Fluid loss is the leakage of the liquid phase of drilling fluid, slurry or treatment fluid containing solid particles into the formation matrix.

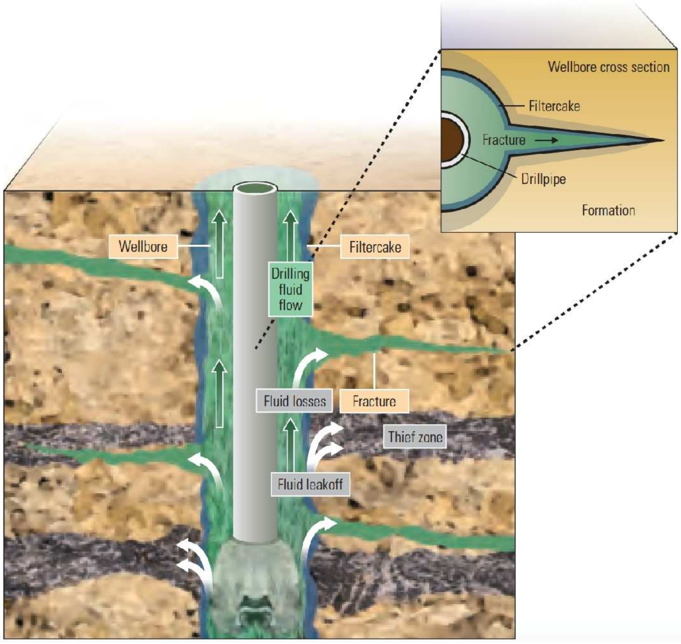

Figure 1 – Pictorial description of drilling fluid loss [1]

When drilling mud is pumped into the wellbore, it passes inside of the drill column, then out through the nozzles of the drill bits into the wellbore annulus. As it makes its way up out of the wellbore, the fluid makes contact with the un-cemented wellbore. The hydrostatic pressure in wellbore is usually more than the formation pressure (this is called over-balanced drilling), which helps to prevent the formation fluid from escaping into the wellbore. In some other cases, when drilling highly permeable rock part of the drilling mud can leak off into the rock while the solid particles or filtrates collect on the wellbore wall and form what is known as a filtercake which actually helps to stop or reduce this leaking off by reason of its low permeability. However, we could have a rock with naturally formed fractures or large pores. The rock's tensile strength could also be lower than hydrostatic pressure thereby causing the rock to fracture, when this occurs, part or even all of the drilling fluid could leak off into these fractures known as thief zones and may even cause further fractures.

If drilling continues during total lost circulation, it is referred to as blind drilling. This is not a common practice in the field, unless the formation above the thief zone is mechanically stable, there is no production, the fluid is clear water and it is economically feasible and safe [2].

Equations 1 and 2 below show the conditions that must be maintained to avoid fracturing the formation during drilling and tripping in, respectively.

$$\lambda_{eq} = \lambda_{mh} + \Delta\lambda_{af} < \lambda_{\text{frac}} ; \quad (1)$$

$$\lambda_{eq} = \lambda_{mh} + \Delta\lambda_{s} < \lambda_{\text{frac}} , \quad (2)$$

where λ_{mh} = static mud weight, $\Delta\lambda_{af}$ = additional mud weight caused by friction pressure loss in annulus, $\Delta\lambda_{s}$ = additional mud caused by surge pressure, λ_{frac} = formation-pressure fracture gradient in equivalent mud weight, and λ_{eq} = equivalent circulating density of mud [2].

Impact Of Fluid Loss

Drilling Mud constitutes about 15 % of the drilling process cost with a single well costing approximately $8.7million in 2013 according to the Petroleum Services Association of Canada. Lost circulation always has been one of the most costly issues facing the industry. Lost circulation gives rise to nonproductive time spent on regaining circulation. Lost circulation was responsible for more than 10 % of nonproductive time spent when drilling in the Gulf of Mexico between 1993 and 2003. The inability to cure losses and resume drilling may, in the worst case, necessitate sidetracking or abandoning the well [2, 3, 4].

The economic impact of lost circulation includes, in addition, the costs of the lost drilling fluid and of the treatment used to cure the problem. According to one estimate, the cost of drilling fluids amounts to 25–40 % of total drilling costs [5]. Given that both regular drilling fluids and lost circulation materials are often quite expensive, the direct economic impact of losing these substances into the formation may be substantial. The cost issue is especially relevant for oil-based muds that are usually more costly than water-based fluids. In addition to the direct economic impact (cost of expensive drilling fluid and nonproductive time), lost circulation may cause additional drilling problems. In particular, the reduced rate of returns may impair cuttings transport out of the well. This leads to poor hole cleaning, especially in deviated and horizontal wells. Poor hole cleaning may eventually result in pack-offs and stuck pipe [6, 7].

The drilling industry has suffered a lot because of lost circulation. In the United States and Canada, a well that has lost circulation will have a mud cost of anywhere from $8000 to $50000. This is not including the rig costs because of the time lost, damage to the drill pipe and/or blowout [6, 7, 8, 9].

Tackling Fluid Loss

Total prevention of fluid loss during drilling is virtually impossible, as early noted, reason being that certain rocks zones have natural caverns, fractures, large pores, or high permeability. However, the problem of fluid loss can be mitigated with these measures listed below:

- Maintaining proper mud weight.
- Setting casing to protect upper weaker formations within a transition zone.
- Updating formation pore pressure and fracture gradients for better accuracy with log and drilling data.
- Minimizing annular-friction pressure losses during drilling and tripping in.
- Avoiding restrictions in the annular space.
- Treating the mud with loss of circulation materials (LCMs).
- Leakoff test (LOT).
- Formation integrity test (FIT).
- Fluid loss additives (FLAs).
- Seal-off plugs.

While applying any of these listed methods a lot of money, time and resources can be saved. FLA has in recent time gained popularity as a preventive measure for controlling loss of circulation.

Types Of Fluid Loss Additives

The different types of fluid loss additives can be divided into 2 kinds namely cellulose derivatives and starch derivatives. The major difference between both is that the starch derived fluid loss additives like HM-FL TROL are frequently used under HP/HT conditions, at which point rapid hydrolysis and degradation take place [10].

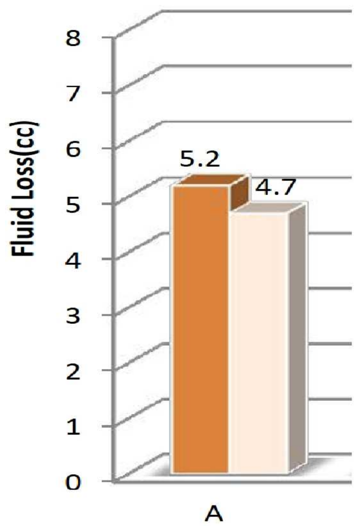

Figure 2 – Fluid loss of Cellulose derived FLA at high temperature of 250 ºF [11]

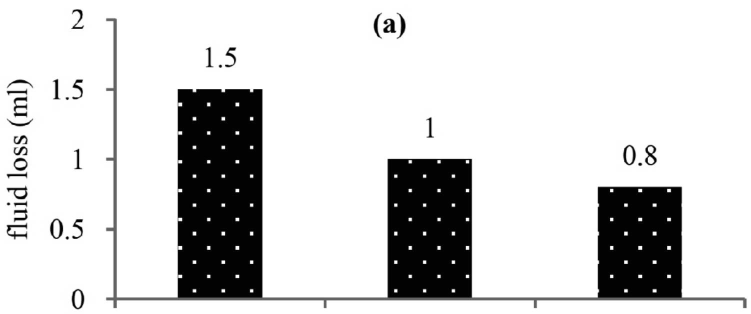

Figure 3 – Fluid loss of starch derived FLA at high temperature of 250 ºF [12]

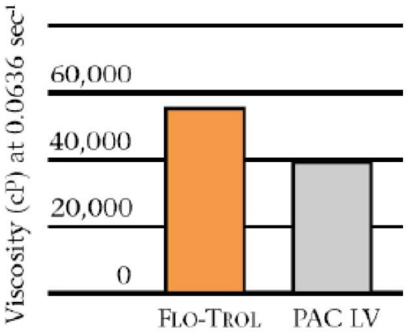

Figure 4 – Comparing viscosity of starch derived FLO-TROL with cellulosic PAC LV [14]

As shown in the graphs, we see that temperature is a very important factor affecting the ability of fluid loss additives to prevent fluid loss during drilling. Starch derived fluid loss additives have an advantage over cellulosic when drilling horizontal wells in complicated conditions for the following reasons:

Firstly, because they have lower values of fluid loss at an abnormally high temperature.

Secondly, because it has higher plastic viscosity, which means more carrying capacity. This is a very important parameter when drilling horizontal wells.

Table 1 – Drilling parameters of a horizontal well «WELL-18» in a Nigerian offshore oilfield «X»

Height (Ft)	Formation temperature (ºF)	Applied Fluid-loss additive	Filtrate (ml/min.)	Deviation
743–2517	94–119	PAC L	2	Slightly deviated
4738–7049	250	HAM-FL TROL	2	Highly deviated

PAC L is a cellulosic FLA while HAM-FL TROLL – a starch derived FLA [13, 14]. According to experimental results presented in figures 2-4, it was observed that the cellulosic FLA is more stable. That is why as the wellbore took a fully horizontal inclination of 90° and the temperature became abnormally high, the applied fluid-loss additive was changed from PAC L to HAM-FL TROL. As a result the filtration rate was maintained, uncontrollable loss of circulation prevented and the target zone reached.

Conclusion

The problem of fluid loss when drilling oil and gas wells is usually accompanied by a huge loss of valuable resources, time and money. Therefore, the mitigation of this problem requires that a lot of attention be paid to this issue while drilling. Drilling mud should be treated with the right fluid loss additives appropriate for well conditions, to combat this problem of lost circulation.

Starch-derived fluid-loss additives are preferred over cellulose-derived additives when drilling a horizontal well as it has proved to be more effective due to its increased plastic viscosity and heat resistance.

References:

1. John cook et al. «Stabilizing The Wellbore To Prevent Loss Circulation» oilfield review winter 2011/2012: 23, № 4.
2. URL : http://petrowiki.org/Lost_circulation (Date accessed: 14 March, 2017).
3. Sibusiso Peter Makonjwa «Synthesis & Performance Evaluation Of Cellulose Nanocrystals As A Drilling Fluid Additive For Fluid Loss And Its Impact On The Fluid Rheological Properties». 8 May 2015.
4. Alexandre Lavrov. Chapter 1 – «The Challenge of Lost Circulation». 2016
5. Rehm B, et al. «Managed pressure drilling». Houston (TX): Gulf Publishing Company; 2008.
6. Le´colier E, et al. «Development Of A Nanocomposite Gel For Lost Circulation Treatment» SPE paper 94686 presented at the SPE European formation damage conference held in Scheveningen, The Netherlands; 25e27 May 2005.
7. Abdollahi J, et al. «Underbalanced drilling as a tool for optimized drilling and completion contingency in fractured carbonate reservoirs» SPE/IADC paper 91579 presented at the 2004 SPE/IADC underbalanced technology conference and exhibition held in Houston, Texas, USA; 11–12 Oct 2004.
8. J.M. Bugbee, «Lost Circulation – A Major Problem in Exploration and Development» in Spring Meeting of Southwestern District, Division of Production, Texas, 1953.
9. Ali Datwani «Review Of Lost Circulation Mechanisms With The Focus On Loss To Natural And Drilling Induced Fractures» 2012. MEng project submission to the University of Dalhousie.
10. Thomas and C. David. «Thermal Stability of Starch and Carboxymethyl cellulose-Based Polymers Used in Drilling Fluids». *SPE Journal*, vol. 22, No. 2, pp. 171–180, 1982.
11. Kakoli M et al. «Recommendations for Compatibility of Different Types of Polymers with Potassium/Sodium Formate-Based Fluids for Drilling Operations: An Experimental Comparative Analysis». J Material Sci Eng 2016.
12. Samavati R. et al. «The Prospect of Utilizing a Cassava Derivative (Fufu) as a Fluid Loss Agent in Water Based Drilling Muds» International Journal of Chemical Engineering and Applications, Vol. 5, No.2, April 2014.
13. http://www.barodidp.com/public_idp/pubsdata/Data_Sheets/I_Z/PAC-L.pdf. (Date accessed: 14 March, 2017).
14. http://www.slb.com/resources/other_resources/product_sheets/miswaco/flo_trol.aspx. (Date accessed: 14 March, 2017).