ISSN 2176-5480

22nd International Congress of Mechanical Engineering (COBEM 2013)
November 3-7, 2013, Ribeirão Preto, SP, Brazil
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ANALYSYS OF THE INFLUENCE OF LUBRIFICANT AND SEALANT IN INHIBITED FLUIDS

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Abstract. *The composition of the fluids depends on the specific requirements of each drilling. Among the additives that are part of the composition of the fluids it can be cited the lubricant which has as a function to improve the lubricity coefficient of the fluid and sealant which promotes the control the losses by filtration and formation of adequate coating. The aim of this work is to evaluate the influence of the concentration of the chemical additives: lubricant (vegetal oil high lubricity chemically treated with acids and neutralizing alkalis) and sealant (calcite) as optimizer of lubricity and filtration control agent and formation of adequate cake, respectively of drilling fluids inhibited through the lubricity coefficient and filtrate volume, in the rheological parameters using experimental planning tool. For organized way of minimum amount of experiments it was used the experimental planning method type* 2^2 *with three experiments in the central point. Through the regression of experimental data it was observed the increase in concentration of lubricant and sealant resulted in adequate fluid properties in relation to the lubricity, filtration and coating formation parameters. The rheological properties followed same tendency, that is, the values of apparent and plastic viscosity and yield limit changed with the concentration of the additives.*

Keywords: *inhibited fluids; lubricity; filtration; experimental planning*

1. INTRODUCTION

The incorporation of additives in drilling fluid figures as one of the main alternatives for fitness the properties that must present the fluid in the oil well drilling. The development of drilling fluid became a procedure increasingly specialized, so that all the required properties are acquired by the incorporation of additives developed specially to fix and/or improve the performance of the fluids during the well drilling operation, thus ensuring the success of the process (Barbosa, 2007).

The drilling fluids present several physical and chemical properties that must be taken into account during its application and can be highlighting the rheological parameters that influence directly in the calculation of load loss in the pipes and in the clean the well. In the field, the rheological properties of interest which is linked to the performance of the fluids are: apparent viscosity, plastic viscosity and yield limit. Other highly relevant properties are the filtrate volume that evaluate the control by loss filtration and lubricity coefficient that is related to the ability of the drilling fluid lubrication capacity (Lucena, 2010; Farias, 2009).

The composition of the fluids depends on the specific requirements of each perforation. In situation of difficult perforation as in well of great depths, directional well and perforation containing reactive formations, it is need a more elaborate fluid, with introduction of one or more additives (Vidal, 2007).

During drilling of oil well it is common to detect the layers consisting of clay minerals with high degree of hydration, organized in lamellar packages. When in contact with water, the clays agglomerates separated as the water penetrates in the basal space (Amorim, 2006). For drilling of such layers with aqueous fluids there is the need of inhibitors of clay with the aim of to prevent the incorporation of drilled solids to the drilling fluid, swelling and the collapse of the walls of the well. It can be called inhibitor any chemical compound that prevents the hydration of the clays (Pereira, 2006; Serra, 2003).

Many difficulties are found during the drilling of oil wells in addition those relating to layer expansion of high degree of hydration. There is, for example, that in directional and vertical well the friction forces between the perforation column and the walls of the well, which can cause serious problems, such excessive torque on the drill column and decrease in the rate of penetration. High torque and drag may can exceed the capacity of drilling equipment and in the case of directional drilling, can exceed the limit of horizontal deviation of the well. Among the many

ISSN 2176-5480

elements that affect the torque and drag, the friction coefficient is the determining factor (Argillier, 1996). These problems can be minimized or even prevented, by the use of suitable fluids with lubricating capacity, achieved by means of additives as lubricants. The lubricants are substances that placed between two surfaces form a protective film that has as main function to reduce friction, wear, temperature control, assist in providing clearing of the equipment, protecting against corrosion from the oxidation process, and may also be agent of force and movement (Medeiros, 2008).

Beyond the control of swelling formation composed by hydratable materials and a lubricant action that a fluid must present another indispensable feature for the proper progress of the drilling operation is the fluid ability of to plug the pores when the bits is drilling the rock, thus avoiding the liquid flow to the rock formation. For this, the fluid must have solid particles with size slightly below the pore size of the exposed rock. These solids are known as sealant (Tarazona, 2008).

So, the aim of this work is to evaluate the influence of chemical additives concentration, lubricant (vegetable oil of high lubricity treated with acids and alkali neutralizing) and sealant (calcite) as lubricity optimizer, filtration control and cake formation agent, using experimental planning tool.

2. MATERIAIS

To prepare drilling fluids it was used the additives listed in Table 1.

Table 1: Additives used in the drilling fluids formulations.

Additives	Unity	Concentration
Anti-foam	drops*	6
Viscosifier	g/350mL	0.75
Filtration reducer	g/350mL	3.0
pH controller	g/350mL	1.0
Swelling inhibitor of expansive clay	g/350mL	16.0
Bactericide	g/350mL	0.7
Lubricant	%	1 a 3
Sealant	g/350mL	15.0 a 25.0

* lb/bbl x 0.00285301 = 1 g/mL

3. METHODS

3.1 Experimental planning

To evaluate the influence of input variable (lubricant and sealant) on the rheological properties (apparent and plastic viscosity and yield point), lubricity (lubricity coefficient) and filtration (filtrate volume) of the drilling fluids, it was used factorial planning 2^2 types with three experiments in the central point, totaling 7 experiments. The matrix of the factorial planning experiments used is shown in Table 2.

The levels of independent variables used in ascending order (-1, 0 +1) were 1%, 2% and 3%/350 mL of water to lubricant (L), and 15, 20 and 25g/350mL of water to sealant (S).

The experimental data regression was performed using the Statistica™ program (Statsoft, 200).

ISSN 2176-5480

Table 2: Factorial planning matrix 2^2 type, with three experiments in the central point.

Fluid	Lubricant (L)	Sealant (S)
F1	-1	-1
F2	+1	-1
F3	-1	+1
F4	+1	+1
F5	0	0
F6	0	0
F7	0	0

3.2 Preparation of drilling fluids

The drilling fluids were prepared according to the common practice, which is to add additives, one by one, under stirring and constant velocity of 13000 rpm in a Hamilton Beach 936 model stirrer, and following the order described in the Table 1.The additives and the amount of each one are also presented in Table 1.

3.3 Rheological study of drilling fluids

24 h at rest, it was done the rheological study of the drilling fluids. For this, the fluid was stirred for 5 min in a Hamilton Beach stirrer at 17000 rpm. The fluid was transferred to the container of the Viscometer Fann 35A model. The viscometer was turn on at 600 rpm and the reading was taken after 2 min. Soon after, the speed was changed to 300 rpm and the reading was taken after15 s.

With the data from the viscometer it was calculated apparent (VA) and plastic (VP) viscosities and yield point (LE). The VA is the value of the reading at 600 rpm divided by 2, given in cP. Plastic viscosity (VP) is the difference in readings obtained at 600 rpm and 300 rpm, also given in cP and LE is the difference between the value obtained in the reading at 300 rpm and plastic viscosity, given in cP.

3.4 Filtrate volume

To estimate the filtrate volume, the fluids were stirred for 1 min, in mechanical stirrer, Hamilton Beach model 936, at 17000 rpm, according to API standard (2005). The fluid was transferred to the filter press API container and submitted to a filtration at 7.0 kgf/cm^2 (100 psi). After 30 min, the filtrate volume was read and given in mL.

3.5 Lubricity coeficient

For the estimation of lubricity coefficient it was used a lubricity tester Ofite maker. It was used a methodology suggested by the manufacturer, that consist in to stir the fluid for 5 min at high rotation and soon after transfer to lubricity tester container, leave for 5 min at 60 rpm and zero torque. After it was applied a force of 150 in.lb in the lubricity tester arm and made reading after 5 min. From this reading it was calculated the lubricity coefficient (CL) according to the Equations 1 and 2.

$$FC = \frac{34}{\mathrm{Re}ading_{water}} \qquad \text{Equation 1}$$

$$CL = \frac{\left(\mathrm{Re}ading_{fluid} x FC\right)}{100} \qquad \text{Equation 2}$$

ISSN 2176-5480

being:

FC=correction factor;
Water Reading = Reading from lubricity tester, with deionized water;
Fluid reading = Reading from lubricity tester, with fluid;
CL = Lubricity coefficient (dimensionless)

4. RESULTS AND DISCUSSION

Table 3 presents the analysis of the variance and the codified mathematic models to the rheological properties (VA, VP and LE), for the filtrate volume (VF) and lubricity coefficient (CL) of drilling fluids.

Though the results it was possible to estimate the regression coefficient (Table 3) for all five answers of interest and so carry out the analysis and to obtain the surface response.

By ANOVA analysis, presented in Table3, it was observed that the models describe the responses VA, VP, LE and VF as a function of studied variables, with statistically significant parameters. The percentage of explained variation for the fluids is 92.89%, 95.42%, 94.17%, 94.79% and 97.46% for the VA, VP, LE, VF and CL, respectively.

According to the analysis of Table 3, it was observed that the mathematic models obtained for all response variables analyzed (VA, VP, LE, VF and CL) are statistically significant, because the ration between $F_{calculated}$ and F_{tabled} was superior to 1.

It was observed the influence of independent variable of the drilling fluids on the rheological properties, filtration and lubricity by mean of analysis of surface response to each of these parameters.

Table 3: Analysis of variance (ANOVA) and codified mathematical models of apparent (VA) and plastic (VP) viscosities, yield point (LE), filtrate volume (VF) and lubricity coefficient (CL) of inhibits fluids to the factorial planning employee.

Source of variation	**Response of variable**				
	VA (cP)	**VP (cP)**	**LE (N/m^2)**	**VF (mL)**	**CL**
Correlation coefficient (R)	0. 936	0. 976	0. 970	0. 973	0.987
% of explained variation (R^2)	92.89	95.42	94.17	94.79	97.46
$F_{calculated}$/ F_{tabled}	1.54	2.26	1.99	1.96	1.05

Codified mathematical models

VA (cP) = 56.35* + 3.00*L + 0.50S + 0.25LS

VP (cP) = 29.43*+ 0.50*L + 2.00*S - 0.50LS

LE= 54.72*+ 16.00*L + 1.00S + 5.00LS

VF (mL) = 7.25*- 0.2*L – 1.00*S - 0.00LS

CL=CL = 0.105* - 0.017*L – 0.017*S - 0.10LS

*statistically significant with 95.0% of reliability.

Significant variations were observed in the rheological and filtration properties of fluids. The fluid F4 has in his composition highest amount of additives (lubricant and sealant) and presented the highest values of rheological properties (VA, VP and LE). These results (Table3 and Figures 1 to 5) may indicate that the increase in the amount of additives for fluids leads to increase in values of rheological properties. In the case of the sealant such increase may be is related to the increase in the content of solids in the fluids that can lead to an increase in the properties related to the fluid flow.

In relation to the values of VF it was observed that the fluids with the highest content of sealant (F3 and F4) showed the lowest values of filtrate volume (6.8 and 6.6, respectively), i. e., the increase in its concentration implies a decrease

ISSN 2176-5480

in this properties. This behavior proves the effective action of this additive in reduction the loss by filtration, because it helps in the formation of a cake, that is, the increase of its concentration implies a reduction of the filtrate.

In Figures 1, 2 and 3 it can be verified the action of the lubricant and sealant from the response surfaces, using codified mathematics models presented in Table 3, for VA, VP and LE properties, respectively. In Figure 4 and 5 it can be observed the influence of these variables in the behavior of the fluids in relation to loss by filtration and lubricity coefficient, respectively.

The values of rheological properties of apparent (VA) and plastic (VP) viscosities showed significant variation with changing in additives concentration, as can be seen in Figures 1 and 2, where the largest concentration of additives resulted in an increase in the values of such properties. This behavior in relation to the concentration of additives may be due to the increase in solids content in the drilling fluids in the case of sealant and for the lubricant may be related with the high molecular weight (close to 800 g/mol) of surfactant that form a film on the surface capable to develop strong interactions.

From the response surface analysis obtained for yield point (Figure 3), it can be observed that this property follows the same tendency of other rheological properties, showing an increase with its increased concentration of additives, i. e., lubricant and sealant. The yield point is related with the minimum force required to fluid start to move, i. e., the force required to break the electrostatic bonds, and a greater additives concentration implies in a greater number of bonds to be broken up [22].

Figure 4 present the response surface for filtrate volume and show the interaction of the lubricant and sealant. In this case, it is observed that the smallest value for VF is obtained when using the higher mass fraction of two additives. This result shows that the sealant acts strongly on the loss by filtration, performing thus as expected, since the sealant has as function to help in the reduction of losses by filtration, i.e., to reduce the filtrate. It also observed that the joint action of lubricant and sealant is very efficient in the reduction of filtrate volume to values close to 6 mL, very expressive and important in aqueous drilling fluids.

Figure 5 presents the response surface for lubricity coefficient. It is possible to see that the values of CL of fluids changing from 0.094 for fluid F4 (3.0% of lubricant) and 0.139 for fluid F1 (1.0% of lubricant). According to these results, it can be observed that the CL presents variations with the increase in the amount of lubricant in the drilling fluid.

According to Darley and Gray (1988) fluids with lubricity suitable must present values of CL close to 0.1 and is this value is commonly found in found in oil-based drilling fluids. In this way, it can be see that most of the prepared fluids presented satisfactory CL, with values below to 0.1.

Fluids with less lubricity coefficient were generally those who had higher content of lubricant in their composition. Such behavior is due to the lubricant characteristics, which is composed of a mixture of vegetable oil. It is fats extracted from plants, contain insoluble esters in water and form a droplet that is dispersed in the liquid. These droplets are extremely small, and have the appearance of a soluble product, and are responsible for fluid lubricity.

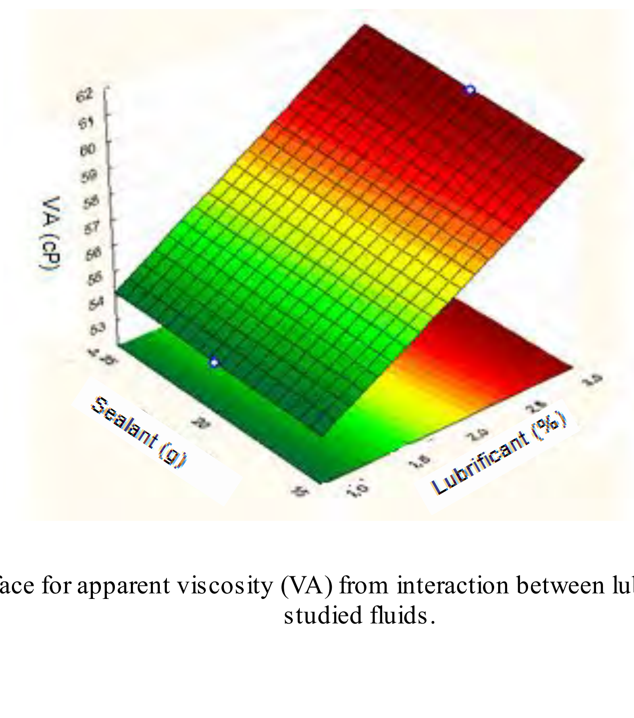

Figure 1: Response surface for apparent viscosity (VA) from interaction between lubricant and sealant additives for studied fluids.

ISSN 2176-5480

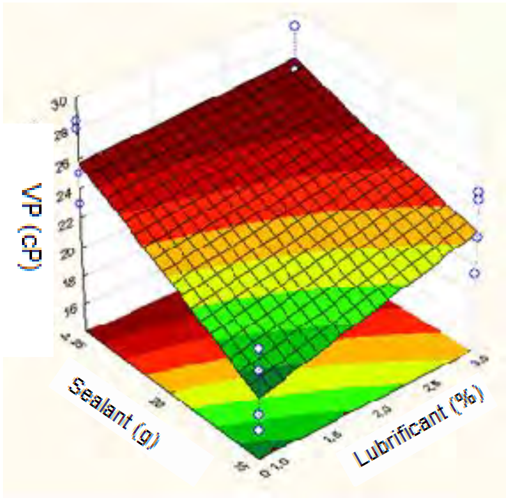

Figure 2: Response surface for plastic viscosity (VP) from interaction between lubricant and sealant additives for studied fluids.

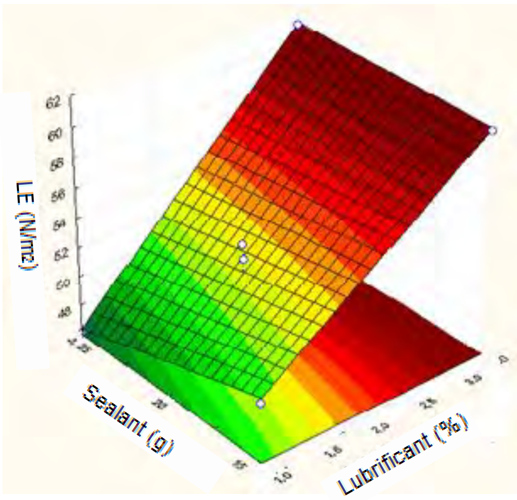

Figure 3: Response surface for yield point (LE) from interaction between lubricant and sealant additives for studied fluids.

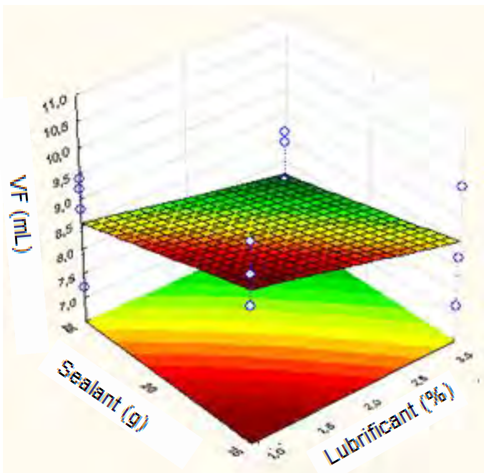

Figure 4: Response surface for filtrate volume (VF) from interaction between lubricant and sealant additives for studied fluids.

ISSN 2176-5480

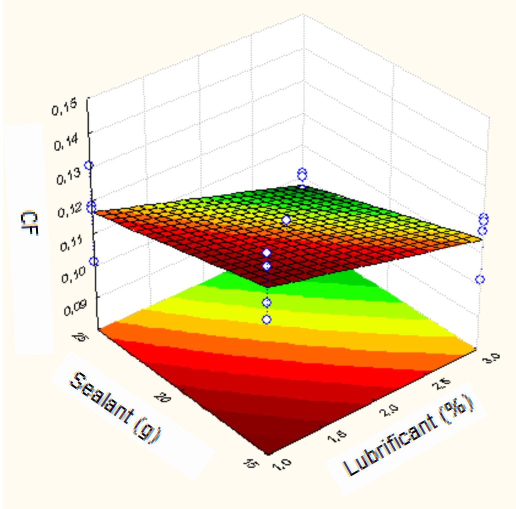

Figure 5: Response surface for lubricity coefficient (CL) from interaction between lubricant and sealant additives for studied fluids.

5. CONCLUSIONS

With the aim to evaluate the influence of the concentration of chemical additives of lubricant and sealant as lubricity optimizer and filtration control agent and formation of cake, respectively, of inhibited drilling fluids through the rheological parameters, lubricity coefficient and filtrate volume, using experimental planning tool, it was concluded that:

- The lubricant is an independent variable statistically significant in the level of 95.0% of confidence for all studied properties (VA, VP, LE, VF and CL);
- The increase in concentration of lubricant significantly increase the values of lubricity coefficient, playing, so their function;
- The fluid F4 presented the best performance, probably because of the greater concentration of additives used in the composition established by experimental planning;
- The study of fluids through the response surface pointed out that the higher concentration of additives (lubricant and sealant) in the fluid greater is the values of rheological properties (VA, VP and LE) and lower is the values of VF.

6. ACKNOWLEDGEMENTS

To CAPES and CNPq (Process N° 305729/2010-1) by providing financial support, to System Mud Indústria e Comércio Ltda by the supply of additives and to the Laborótorio de Pesquisa em Fluidos de Perfuração – PEFLAB of the LABDES/UFCG.

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