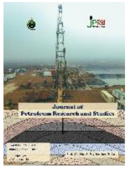
Journal of Petroleum Research and Studies

journal homepage: https://jprs.gov.iq/index.php/jprs/

Print ISSN 2220-5381, Online ISSN 2710-1096



Aphron-Microbubbles: A Friendly Innovation in Enhancing Water-Based Mud Performance for Future Drilling Operations in Iraqi Depleted

Waleed K. Mutter [1,2*], Faleh H. Mohammed[1], Maryam M. Ahmed[3]

[1]Department of Petroleum Engineering, College of Engineering, University of Baghdad, Iraq.
[2]North Oil Company, Ministry of Oil, Iraq.
[3]Petroleum Research and Development Center, Ministry of Oil, Iraq.
[*]Corresponding Author E-mail: Waleed.khalaf2208m@coeig.uobaghdad.edu.iq

Article Info

Received 05/03/2024
Revised 20/05/2024
Accepted 23/05/2024
Published 21/09/2026

DOI: http://doi.org/10.52716/jprs.v16i3.933

Abstract

Microbubble-based Aphron drilling fluids (ADFs) are becoming a viable option of the mud system in the oil and gas sector nowadays and for good reason, they can pass through reservoir rocks without being left inside the tiny pores. Surfactants are the source for developing microbubbles inside the conventional drilling and completion fluids that improve the main characteristics of the drilling mud including density, rheology, filtration and wellbore stability. Most of the oilfields in northern Iraq are in the state of depletion and can't be drilled using the conventional drilling fluids due to the lost circulation and instability problems.

This study investigates the role of Aphron -a microbubble drilling fluid that excels in decreasing the potential of circulation loss inside the borehole by minimizing the differential pressure. Hence, several ADFs with low density were developed using environmentally friendly surfactants, such as CTAB and SDBS at different concentrations. All the necessary measurements of density, pH, viscosity, gel strength and filtration properties were performed according to the American Petroleum Institute (API) standards.

The obtained results show that Aphron-microbubbles have a major impact on the density where it was lowered by 32%. In addition, the fluid loss rate was lowered by 46% with 0.15% w/v of the SDBS surfactant.

Keywords: Aphron -microbubbles; Drilling fluid; Filtration; Rheological properties; Low-weight mud.

أفرون-الفقاعات الدقيقة: أبتكار صديق في تحسين أداء الطين المائي لعمليات الحفر المستقبلية في المكامن العراقية المستنفذة

الخلاصة:

أصبحت سوائل الحفر القائمة على الفقاعات الدقيقة أفرون خيارا قابلا للتطبيق لنضام الطين في قطاع النفط والغاز في الوقت الحاضر ولسبب وجيه، يمكنه المرور عبر صخور المكمن دون تركها داخل المسام الصغير. المواد الخافضة للتوتر السطحي هي مصدر تطوير الفقاعات الدقيقة داخل سوائل الحفر والكمال التقليدية. حيت تعمل تلك الفقاعات على تحسين الخصائص الرئيسية لطين الحفر بما في ذلك الكثافة،

الخصائص الريولوجية، الترشيح، واستقرار حفرة البئر. أن معظم حقول النفط في شمال العراق في حالة نضوب ويصعب حفرها بأستخدام سوائل الحفر التقليدية بسبب فقدان دورة سائل الحفر ومشاكل عدم الاستقرار.
تبحث هذه الدراسة في دور الأفرون- سائل الحفر الذي يتفوق في تقليل احتمالية فقدان دورة سائل الحفر أثناء الحفرعن طريق قليل الضغط التفاضلي بين سائل الحفر والتكاوين المستنفذة. تم تحضيرعدة نماذج من سائل حفر أفرون ذات الكثافة المنخفضة باستخدام نوعين من المواد المقللة للشد السطحي CTAB, SDBS بتركيزات مختلفة ثم اجراء اجراء القياسات المختبرية اللازمة مثل الكثافة، درجة الحامضية، اللزوجة، قوة الهلام وخصائص الترشيح وفقا لمعايير معهد البترول الامريكي.
تظهر النتائج التي تم الحصول عليها أن الفقاعات الدقيقة-أفرون أثرت بشكل كبير على الكثافة حيث تم تخفيضها بنسبة 32% . بالأضافة الى ذلك انخفض معدل الترشيح (فقدان السوائل) بنسبة 46% عند تركيز 0.15% من الفاعل بالسطح SDBS.

1. Introduction

Drilling the depleted or low-pressure reservoirs with overbalanced drilling fluids (conventional drilling mud) often lead to costly problems, such as lost circulation and pipe differential sticking. Meanwhile, using underbalanced drilling or aerated drilling fluids requires special equipment and additional safety precautions. In addition, providing the balanced hydrostatic pressure for formations above the low-pressure reservoir is challenging, thus, these problems in low-pressure layers can be avoided using a specialized drilling mud that has recently been developed. This mud is commonly referred to as Aphron-based drilling fluid (ADF) which is known for its high shear-thinning nature and remarkable low-shear-rate viscosity (LSRV) with minimal thixotropy [1, 6].
ADFs are not dependent on the conventional bridging agents for sealing the loss regions. However, employ a unique composition of the surfactant to produce Aphron's microbubbles that are encapsulated within the continuous aqueous phase of the liquid [2]. ADFs can replace the functions of the conventional air-based drilling fluids at relatively low concentrations of surfactants using the standard mud circulation equipment. This process traps air to a level determined by the surfactant's concentration of Aphron-generation where the need for additional especial equipment is eliminated [3]. Introducing the surfactant within the drilling fluid plays a crucial role in converting the entrained air into the stable Aphron s or highly stabilized microbubbles. These microbubbles display stability under downhole conditions, effectively establishing internal bridging in low-pressure reservoirs. This, in turn, prevents uncontrollable fluid loss and minimizes formation damage in depleted reservoirs [3-5]. Brookey [6] in 1998 introduced the concept of Aphron s or energized air bubbles in the oil and gas industry. Afterwards, Brookey and his co-authors performed several studies on the application of ADFs in West Texas, specifically in drilling a horizontal re-entry well through fractured dolomite in the Fusselman field [5]. Since then, Aphron -based drilling fluid, known as water-based micro-bubble drilling fluid (WMDF), has gained widespread usage in drilling thousands of depleted reservoirs with no reported circulation loss issues [6 -11]. In 2010, he reported a comprehensive overview of the application ADFs

considering the laboratory and field data in China. According to the outcomes of his study, it has been stated ADFs can exhibit a high performance in drilling the under-pressured zones due to their unique properties and bridging mechanism [12]. In addition, the properties of ADFs developed from a combination of surfactant and xanthan gum was studies by Arabloo et al. [13]. Their findings revealed that an increase in xanthan gum polymer concentration led to a reduction in Aphron's bubble diameter, while an increase in surfactant concentration resulted in larger bubble diameter. They also demonstrated that elevating both surfactant and polymer concentrations contributed to an increase in the apparent viscosity, plastic viscosity and yield point of ADFs-based drilling fluids [13].

The ultimate goal of this study was to investigate main properties of ADFs developed using CTAB and SDBS, such as density, pH, filtration loss and rheological behavior. Five samples of ADFs contain SDBS, as microbubble generator, at different concentrations, were tested in laboratory at the same conditions.

1.1. Area of Study

X Field is the one of the most important Iraqi oilfields as shown in Fig.1, located north-west of the Kirkuk city. Tectonically, the field is located within the hill region of the northwest-southeast oriented to Zagros Fold mountains and Thrust Belt. In 1953, this oilfield was discovered by the Iraqi Petroleum Company (IPC) and start on production in 1960 [14]. X field construction is a double-plunged anticline and asymmetrical of 3.8 km wide and 34 km length [15]. (Figure 1) highlight the oil fields in northern Iraq. Currently, the X oilfield produces from two known main reservoirs. [16]. As production continued in this field, the pressure started decreasing inside the reservoir and led to making a big difference in the balance between the pressure of the mud column (hydrostatic pressure, HP) and formation pressure (FP) while drilling operations. Hence, the high differential pressure (DP) will increase challenges of the drilling process and production. These challenges are the occurrence of partial loss circulation and consumption in time and treated materials along with the reservoir damage. Consequently, it causes a delay in early oil production and production operations in the long run. Equations below shows the effect of density of differential pressure.

$$DP = HP - FP \quad \text{.......} (1)$$

$$HP = 0.052 \times \rho \times h \quad \text{.......} (2)$$

Where ρ is the density of drilling fluid in ppg and h is the height of the mud column in ft.

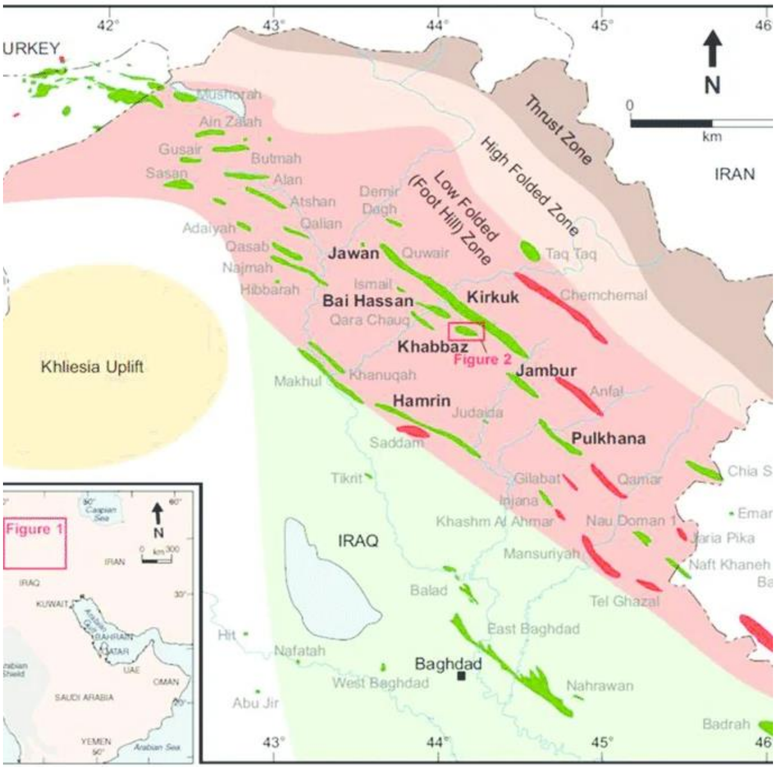


Fig. (1): X Oilfield in Northern Iraq

2. Experimental Work

2.1. Materials

ADFs contain two main materials which are polymer as viscosifier additive and surfactants [19]. In this study, Xanthan (XC) polymer and CTAB and SDBS surfactants work as Aphron 's stabilizer and generator were used for the preparation of the ADFs. In the formulation of Aphron -based drilling fluids, careful consideration of the surfactant is decisive to maintain the existence of bubbles within the drilling fluid. As the surfactant chosen for Aphron ization, focused on ionic surfactants, specifically Sodium Dodecyl Benzene Sulfate (SDBS) and Cetyl Trimethyl Ammonium Bromide (CTAB). The chemical formula of SDBS is $CH_3\ (CH_2)_{11}C_6H_4SO_3Na$ an anionic surfactant, was the pioneering choice in previous research for successfully generating Aphron s [20-21]. Arabloo [22] demonstrated that an anionic surfactant produces adequately stable Aphron s in the base mud. The second surfactant used is Cetyl Trimethyl Ammonium Bromide, a water-soluble cationic surfactant, which served as a stabilizer and dispersion agent (prevent bubbles to merging) for microbubbles that generated by anionic SDBS surfactant. The chemical formula of CTAB; $C_{19}H_{42}BrN$. CTAB has been utilized by other researchers in ADFs formulation [23-26]. Figure (2) illustrated the picture of chemical structure of CTAB and SDBS respectively.

Fig. (2): Chemical structure of CTAB and SDBS surfactants used in this study.

2.2. Preparation of BDF and ADFs

The based drilling fluid (BDF) was prepared by mixing distilled water, caustic soda, soda ash, bentonite and Xanthan polymer (XC) together using a Hamilton beach mixer at 10000 RPM and agitated for 20 minutes in 350 mL special container (Figure 3). After 20 hrs of prehydrating the BDF was mixed again for 10 minutes at same speed, then Aphron ized by CTAB as Aphron s stabilizer and specific concentrations of SDBS as Aphron s generator. In this way, the base drilling fluid and surfactant mixture was homogenized for five minutes at the speed of 10000 RPM. All these drilling fluids (BDF and ADFs) were prepared and their characteristics were tested in the drilling fluid laboratory of the North Operations Branch of IPC.

Fig. (3): Shown three ADFs samples prepared and Hamilton Mixer.

2.3. Formulation of Testing Drilling Fluids

Table (1) shows the concentration of materials that were used in density, pH, thermal rheology and API filtration tests. As can be seen, the concentration of both XC polymer and CTAB is constant in each density, pH, thermal rheology and filter press measurements, while the concentration of SDBS is wide-ranging. the XC polymer concentration in these tests is 0.3% (1 gram) compared to the CTAB concentration of 0.2% (0.7 gram). In density, pH, thermal rheology, and filter loss tests the concentration of the SDBS surfactant varied in the investigation of the effect of the surfactant concentration on the Aphron based drilling fluids properties.

Table (1): Concentrations and function of materials sed

Components	Concentration (%)	Function
Water	100	Continuous phase
Soda ash	0.1	Hardness buffer
Caustic soda	0.1	PH control
Bentonite	6.67	Gel builder
Xanthan polymer	0.3	Viscosifier, filtration control
CTAB	0.2	Aphron -stabilizer, viscosifier
SDBS	(0.05, 0.1, 0.15, 0.2, 0.3)	Aphron generator

2.4. Density Experiments

Density is one of the most important characteristics of the drilling fluid and is prioritized by mud engineers when designing the drilling program because the density of the mud is directly related to other properties of drilling fluids, such as viscosity and filtration, in addition to its effect on the wellbore stability, rate of penetration ROP, and other hydraulic matters. Using the surfactants in aqueous drilling fluids leads to a significant decrease in the mud density. This reduction in density is an attribute to the microbubbles generated within drilling fluid by surfactants. The reduction in drilling fluid density will be reflected directly to the hydrostatic pressure inside the well, as in equation (2) above. The decrease in the hydrostatic pressure of the drilling liquid column will inevitably reduce the pressure difference between the drilling fluid column and the low -pressure formations and thus reducing the possibility of mud loss in those formations. In this study the density of drilling fluids was investigated before and after adding the XC polymer, CTAB and SDBS surfactants by OFITE standard mud balance apparatus, or electronic weight balance when mud density read less than 0.7 gm/cc, as illustrated in Figure (4).

Fig. (4): Showed from left of both standard mud balance and electronic balance.

2.5. pH Experiment

pH is an important characteristic of drilling fluid properties. The pH of drilling fluid must be monitored continuously while drilling, workover and completion operations to minimize equipment corrosion and prevent solubility of claystone minerals. In this examination pH paper strip was used for water-base drilling fluid to determine the alkalinity [OH] or acidity [H] of the aqueous solution. The solution converts to acidic when hydrogen [H] ion concentration increased by substance dissociates the hydrogen [H+] ions whilst the solution can be converted to alkalinity when the hydroxide [OH] ion concentrations increase by substances that dissociates hydroxide [OH+] ions.

2.6. Filtration Loss Experiments

While drilling the permeable formations, drilling fluid loss should reach the lowest possible value to reduce formation damage especially in depleted reservoirs. therefore, drilling fluid loss tests were achieved by API filtration tests on BDF and ADFs under filter pressure 100 psi and room temperature 20 °C. This test was conducted for 30 min and recorded the filtrated volume and mud cake thickness continuously for each sample.

2.7. Rheology Experiments

The rheological properties of the based drilling fluid (BDF) and Aphron s drilling fluids (ADFs) were measured in five different speeds (Ø600, Ø300, Ø200, Ø100, Ø6) by using Vann viscometer (model-800, USA) with a heating cup, under temperatures ranged from 40, 60, to 90 Celsius, as in Figure (5). The thermal stability of the drilling fluid directly influences the rheological properties of the mud (apparent viscosity AV, plastic viscosity PV, yield point YP, and gel strength GS) at elevated temperatures. Consequently, the performance of BDF and ADFs at higher temperatures, including the rheology of the based drilling fluid (BDF), and ADF sample containing the optimal concentration of SDBS surfactant (0.2% w/v) were investigated.

Fig. (5): Vann viscometer and heating cup.

3. Results and Discussion

3.1. Density

Figure (6) showed the results of the laboratory tests show that there is a significant effect of the SDBS surfactant on the drilling fluid density. Where the drilling fluid density decreased with the increase of the SDBS concentration. This decrease in density attributed to an increase in the microbubbles generated. The main advantage of utilizing Aphron -based drilling fluids are their ability to reduce density, which assists in achieving a balance between mud column hydrostatic pressure and formation fluids pressure. this is particularly beneficial when drilling depleted reservoirs. By reducing density, these fluids can minimize the loss of drilling fluid circulation and hence reduce reservoir damage. This approach is preferred to the costly and safety problem related challenges associated with underbalanced drilling processes. The effect of both the CTAB (Aphron stabilizer) as well as XC Polymer has been tested when added together on the density of the drilling fluid, as 0.3% and 0.2% w/v of XC and CTAB respectively, were tests on WBDF and then found the density to equal 1.02 gm/cc. This indicates that both CTAP and XC Polymer have a little effect on the density of the drilling fluid. Consequently, the large decrease in density is due to the SDBS additives. As in Figure (5) is showing.

The results obtained during laboratory experiments are compatible with previous studies as in Growcock [10] study. Which can be said that any increase in the concentration of the Aphron generator (SDBS) leads to notice reducing in drilling fluid density. Laboratory tests proved that increased concentration of SDBS directly will decrease the density of drilling fluid continuously with each increase of SDBS, due to the number of micro bubbles that generated when SDBS added. These microbubbles are being more stable with certain concentrations of XC polymer and CTAB (Aphron stabilizer). Through Figure (6), also it can be observed that the density of the 0.05% w/v SDBS Aphron (0.94 gm/cc) higher compared with other Aphron samples containing on 0.1%, 0.15%, 0.2% and 0.3% w/v of SDBS. This result indicates that the lower addition of SDBS failed to generate a sufficient number of microbubbles, resulting in a less noticeable reduction in Aphron drilling fluid density. Finally, observed that the concentrations 0.1%, 0.15% and 0.2 w/v of SDBS resulted in a more stability decrease in density compared to concentration 0.3% w/v of SDBS. This attributed to the fact that most of microbubbles generated when adding 0.3% w/v of SDBS are unstable and explosible and the reason is due to the override of the balance between the concentrations of Aphron generator (SDBS) and Aphron stabilizer (CTAB), where the last one (CTAB) becomes have a low concentration in system. In other phrase, there aren't sufficient concentrations of the Aphron stabilizer (CTAB) and XC polymer to cover all the generated bubbles at 0.3% w/v of SDBS concentration. Therefore, noted that the density of ADFs starting for increase again due to exploded of most Aphron -bubbles at high SDBS concentration (0.3% w/v). This finding can be explained by considering the balance between the Aphron generator (SDBS) and Aphron stabilizer (CTAB) with XC polymer support are playing a crucial role in microbubbles stability hence ADFs density.

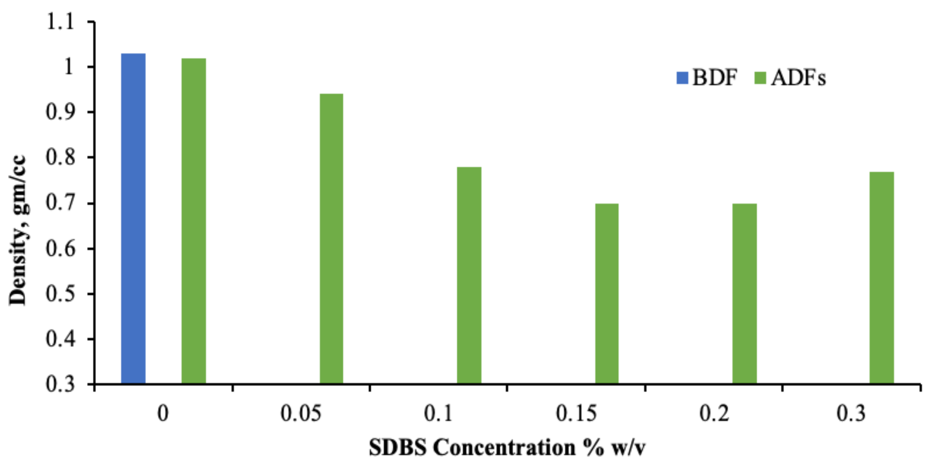


Fig. (6): Shown the effect of SDBS concentration on ADFs density**.**

3.2. pH

The experimental results illustrate the impact of different concentrations of XC polymer, and surfactants (CTAB, and SDBS) on the PH degree of drilling fluid are presented in Figure (7). Notably, the Aphron additives (XC, CTAB, and SDBS) doesn't make large influence on the alkalinity of the drilling mud, maintaining of PH about 9 to 9.5 across with used concentrations of the Aphron additives. This proves advantageous for Aphron drilling fluids, affirming that each of XC polymer, CTAB, and SDBS does not induce chemical corrosion to the drill string or downhole assembly.

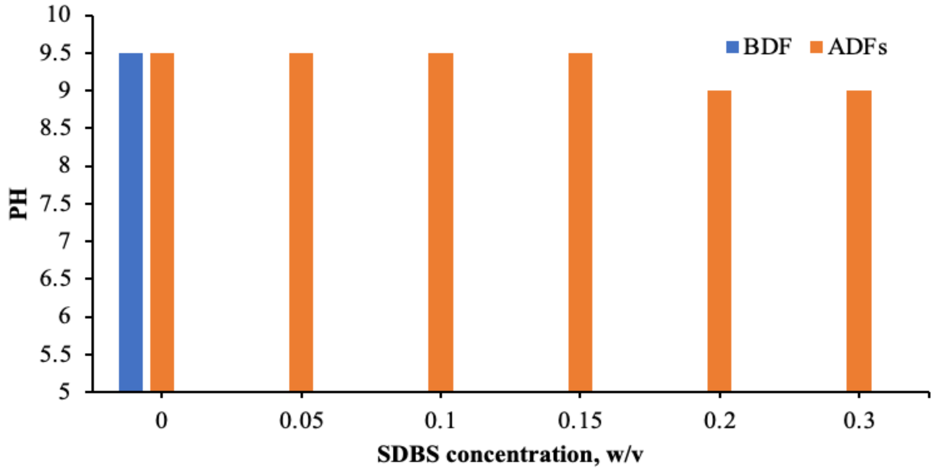


Fig. (7): Shown the effect of SDBS on PH of drilling fluid.

3.3. API Filtration Loss

In this study, API filtration loss testing conducted on the Aphron Drilling Fluid at room test conditions (20°C, and 100 Psi) after added the different concentrations of (SDBS) Sodium Dodecyl Benzene Sulfonate, with the aim to finding the impact of microbubbles on the mud filtration control and compare it with blank mud. The results are presented in the Figure (8) below. It was observed that the addition of SDBS surfactant improved the filter properties of the BDF by reducing the rate of fluid loss over the period of 30 minutes. The monitored trends in the values of API filtration can be ascribed to the presence of microbubbles, generated by the addition of SDBS in the drilling fluid. These microbubbles play a crucial role in filter amount control, affecting on the fluid's filtration behavior during testing. The microbubbles can physically bridge the porous throats and hence reducing the volume of mud loss. The microbubbles dispersed among other ultra-micro size of drilling fluid components act as bridging agents and seal porous voids effectively, hence, producing thin, elasticity, coherent surface of the mud cake.

Through Figure (8), we conclude that the improvement rates in the filtration loss feature of ADFS using (0.05, 0.1, 0.15, 0.2, 0.3) % w/v of SDBS compared to BDF are (33.34, 46.67, 46.67, 40, 20) % respectively. These results show that the Aphronized drilling fluids has greatly controlled the filter loss, this is due to the presence of microbubbles generated by addition of Anionic Surfactant (SDBS). Also in this study, the ideal proportions of the SDBS concentration can be identified through the results of laboratory tests for both density and the filter loss improvements, which is 0.15% w/v for the SDBS because it gave the lowest acceptable density (0.7 gm/cc) for ADFs with the highest improvement in the filtration loss, which is 46.67% compared with BDF. These findings are considering a good result and acceptable with other studies results [27-28].

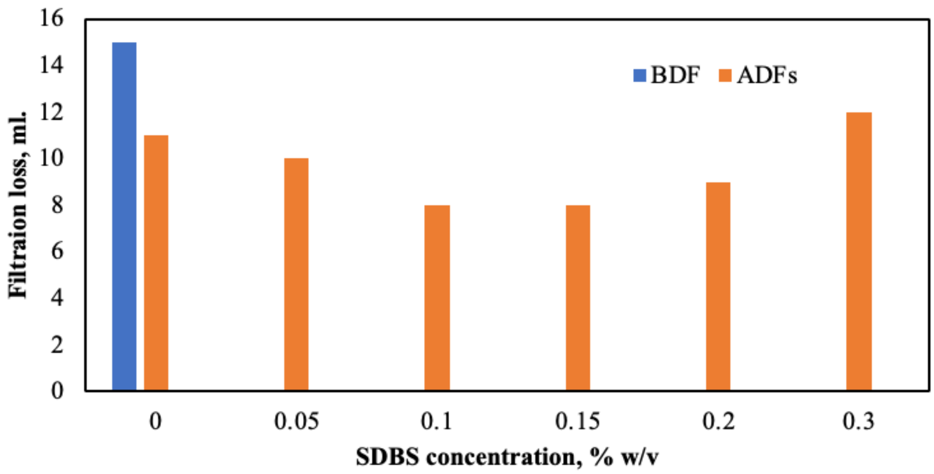


Fig. (8): Shown effected of SDBS concentration on ADFs filtration loss

Noteworthy, that high concentrations of SDBS more than 0.15% w/v showed disadvantage results in the filtrate loss amount, because of the Aphron 's high generator of SDBS concentration (0.2 and 0.3) w/v exceeded the balance state with Aphron 's stabilizer CTAB concentration, this is due to the fact that most of Aphron -microbubbles generated in the high concentrations of Aphron's generator (above 0.15% w/v) lack the sufficient support from the concentration of Aphron's stabilizer. Therefore, these bubbles will explode and lose its role in the bridging process, the filter paper and in reducing the mud filtration, thus increasing the filtrate fluid volume.

3.4. Rheological Properties for ADFs at Elevated temperatures

To evaluate the efficacy of Aphron-based drilling fluid (ADF) in formations characterized by reservoir conditions, the thermal stability for the optimum ADF sample (0.15% w/v of SDBS) was examined. The testing involved gradually increasing temperatures, specifically at 40°C, 60°C, and 90°C. The thermal stability of the Aphron drilling fluid directly influences the rheological properties of the mud at elevated temperatures. Consequently, the performance of SDBS surfactants at higher temperatures, including the rheology of the Aphron-based drilling fluid (ADF) sample containing the optimal concentration of SDBS surfactants was analyzed, as in Table. (2).

Table (2): Shown thermal effect on ADFs rheology

Temp. (°C)	Rheological Properties of Optimum ADF Sample (0.15 % SDBS)						
	Ø600	Ø300	AV cp.	PV cp.	YP Ib/100ft^2	YP/PV Ratio	10sec./10min GS (Ib/100 ft^2)
40	91	70	45.5	21	49	2.34	22/34
60	98	75	49	23	52	2.26	21/32
90	106	80	53	26	54	2.077	18/27

3.4.1. Apparent and Plastic Viscosity of ADFs at Elevated Temperatures

After elevating the temperatures of Aphron s drilling fluid the results for apparent AV and plastic viscosity PV are shown in Figure (9). Where observed, the AV and PV for Aphron ized drilling fluid increased with increasing temperature, this study is an agreement with previous studies [29]. In fact, after Aphron generation, an increase in temperature leads to a decrease in the yield stress of the drilling fluid. However, the generation of Aphron s leads to a possible increase in the yield stress at all temperatures. This is attributed to the addition of surfactant to the system, which elevates the ionic concentration and attractive forces within the fluid. Consequently, it enhances the yield stress, signifying an increase in shear stress required to disrupt the gel structure of the drilling fluid for it to flow. This illustrates that the Xanthan Gum (XC) polymer and surfactants contributed to the enhanced thermal stability of the BDF. Achieved this by maintaining a slow rate of AV increment with increased temperatures. This effect is beneficial in preventing abrupt or sharp decreases in mud viscosity, thereby preserving the mud's integrity and functionality. Moreover, it was noted that the thinning behavior of the Sodium Dodecyl Benzene Sulfonate (SDBS) surfactant remained effective even at elevated temperatures, as evident in both AV and Plastic Viscosity (PV) results. The ADF exhibited higher AV and PV values compared to those of the BDF, the reason is attributed to the increase in the friction force, as well as the electrochemical force of the fluid due to the presence of Aphron -bubbles.

In addition, Figure (9) reveals that a rise in temperature has minimal impact on plastic viscosity (PV), after Aphron s generation therefore, in the post Aphron generation, it appears that PV is a result of interactions involving bubble-bubble, bubble-fluid, and fluid layer frictions. Consequently, electrochemical values after Aphron generation tend to be higher (AV).

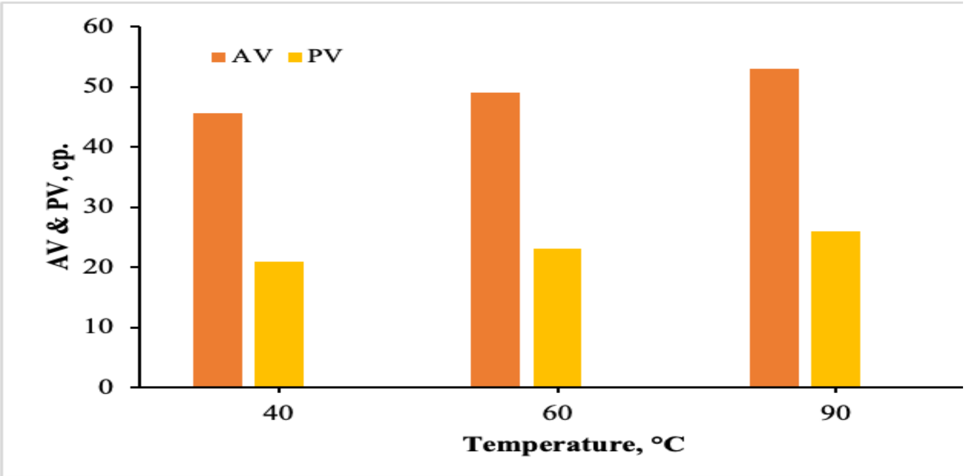


Fig. (9): Shown the Effect of Temperature on AV & PV of ADFs.

3.4.2. Yield Point and Gel Strength of ADFs at Elevated Temperatures

Although the Bingham Plastic Model may not be the most precise in characterizing the rheological properties of Aphron -based drilling fluids, its parameters (PV and YP) are extensively employed in hydraulic computations within the oil field industry. Notably, these parameters play a crucial role in assessing fluid behavior. Prior to Aphron generation, the fluid is more susceptible to temperature fluctuations. Conversely, after Aphron generation, the yield point (YP) increases when the temperature rises. The heightened YP following Aphron generation can be attributed to the addition of surfactant, which augments the electrochemical force within the fluid. Consequently, this surge in intermolecular forces contributes to the observed increase in YP [29] .The results depicting the yield point (YP) and gel strength (GS) of Aphron s drilling fluid (ADF) at elevated temperatures are illustrated in Figure (10). The acceptable incremented YP values of ADF with rising temperatures can be attributed to the increasing electrochemical forces among the microbubbles constituting the Aphron s mud. In simpler terms, the attractive forces between microbubbles strengthens at higher temperatures. This increment in YP has immediate repercussion on the mud's functionality, particularly in hole cleaning, as a significantly high YP hampers its ability to efficiently transport cuttings.

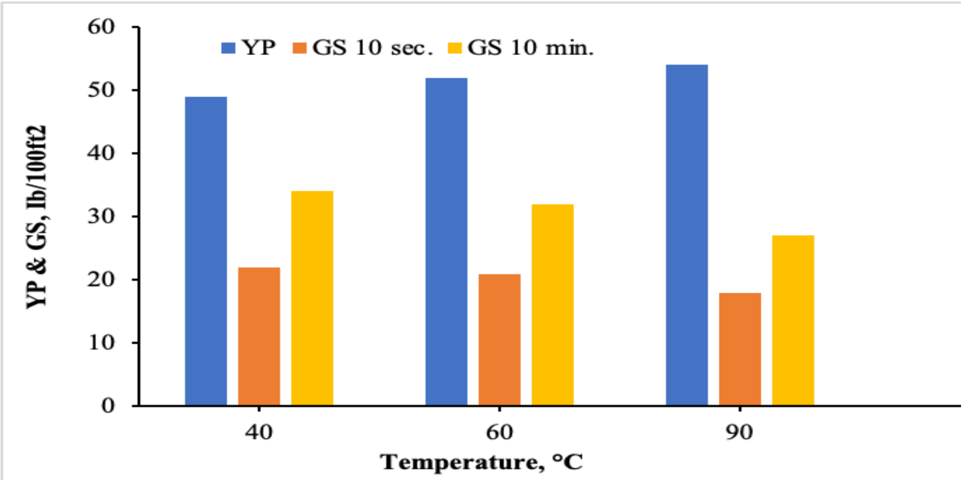


Fig. (10): Shown the Effect of Temperature on YP & GS of ADFs

On contrast of AV and PV, depicted in Figure (10), both the initial gel strength (10 seconds) and the final gel strength (10 minutes) for Aphronized drilling fluid exhibit a decrease with an increase in the temperature. the gel strengths consistently diminish with the increasing temperature of the drilling fluid. This points to the shear-thinning ability of the drilling fluid, where the fluid's flow can overcome the gel strength and transition to its dynamic equivalent, represented by the yield stress. The introduction of surfactants (CTAB & SDBS) and XC polymer to the bentonite water-based mud (BDF) has notably improved the gelation properties by sustaining adequate gel strength values. At 90ºC, the 10-sec gel strength of the Aphron -mud measures 18 lb/100ft^2, while the base mud records only 9 lb/100ft^2 (tested out Figure (9). Furthermore, at 90oC, both the 10-sec and 10-min gel strength of the Aphron -mud exhibit gelation properties equivalent to or closely resembling those of the base drilling fluid at temperatures below 60°C. Essentially, the addition of surfactants (Aphron generator) has significantly enhanced the drilling fluid's ability to retain more rock cuttings at elevated temperatures, contributing to an overall improvement in drilling operations.

3.4.3. Hole Cleaning Capacity of ADFs at Elevated Temperatures

The investigation into the mud carrying capacity of drilled cuttings at different elevated temperatures involved calculating the YP/PV ratio at temperatures of 40°C, 60ºC, and 90°C. The findings, shown in Figure (11). The hole cleaning capacity of Aphron -based drilling fluid experienced a more modest decline with increasing temperatures, demonstrating a stable decrement of about 2.2. Even at temperatures as high as 90oC, the YP/PV ratio did not fall below two, indicating that the mud would continue to function effectively in terms of hole cleaning. It is crucial to maintain a hole cleaning capacity (YP/PV) ratio above 2.0 to guarantee an adequate efficiency. The introduction of Aphron s (microbubbles) played a crucial role in enhancing the

YP/PV ratio of the base drilling fluid at elevated temperatures, thereby sustaining a high and stable YP/PV ratio. This improvement suggests enhanced discharge of drill cuttings by the mud, having a positive impact, resulting in more efficient drilling operations and mitigating challenges related to inadequate downhole cleaning under conditions of this kind. Notably, with the increase of temperature, the Aphron -based mud would exhibit a more stable decline in the YP/PV ratio, characterized by a smooth curve without significant fluctuations.

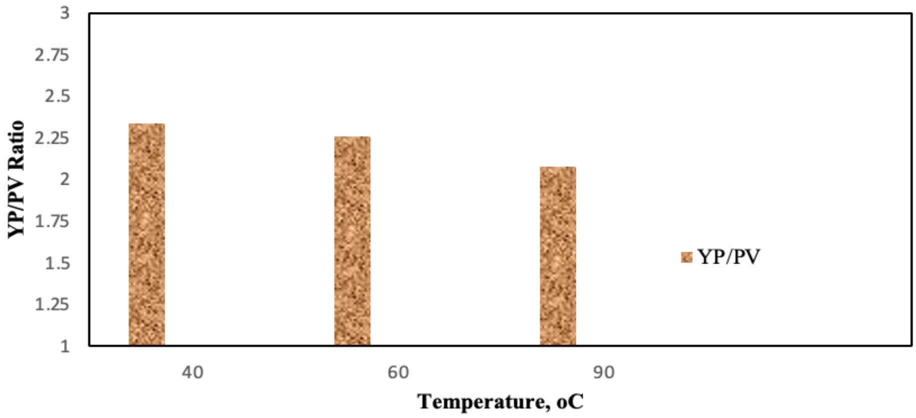


Fig. (11): Shown the Effect of Temperature on Hole Cleaning Capacity of ADFs

4. Conclusions

The effects of XC polymer and surfactants (CTAB and SDBS) on BDF performance can be concluded as follows:

- The addition of XC polymer and cationic surfactant (CTAB) had a negligeable impact on the drilling fluid’s density, this results in a slight reduction from 1.03 g/cc to 1.02 g/cc. suggesting that these materials (XC and CTAB) had limited ability in producing microbubbles in the drilling fluid. Conversely, the addition of the anionic surfactant (SDBS) caused a significant change in the density of Aphron Drilling Fluids (ADFs) lowered by 32% when 0.15% w/v of SDBS was added. This change is attributed to the microbubbles generated by SDBS, indicating a reduction in mud hydrostatic pressures when these fluids are applied.
- The additives used (XC polymer and surfactants) doesn’t have large effect on pH of the drilling fluid. It ranges from about 9 to 9.5. This is a positive indicator for avoiding equipment erosion.
- The key focus of this study was filtration, and it was noted that the anionic surfactant (SDBS) had a substantial impact on fluid filter loss. The filter loss volume decreased from 15 ml for Base Drilling Fluid (BDF) to 8 ml for ADF when SDBS concentrations of 0.1% and 0.15% w/v were added. This represented a 46.67% reduction in filter loss volume compare to BDF, attributed to the presence of Aphron -microbubbles and the associated reduction in hydrostatic

pressure. This improvement in filtration is expected to decrease the probability of formation damage in depleted reservoirs.

- Rheological properties, including viscosity, suspension, and hole-cleaning capacity of ADFs with 0.1% SDBS under high temperatures (up to 90 degrees Celsius), were found to be more efficient. These fluids demonstrate promising technology can apply in Iraqi oilfields to minimize the costs that is results from loss circulation and his materials. In addition, early efficient production of wells and reduced treatment and workover processes.

Acknowledgement

I would like to thank petroleum research and development center and his staffs, especially my research coordinators. Then I would like to thank the Iraqi Drilling Company represented by Professor Eng. Muhammad Aswad Al -Obaidi for the provision of laboratory examination devices. Also, thanks and appreciation to my affiliation, north oil company.

Nomenclatures

XC	Xanthan
CTAB	City-Trimethyl Ammonium Bromide
SDBS	Sodium Dodecyl Benzene Sulfate
CGA	Colloidal Gas Aphron
UBD	Under Balance Drilling
ADF	Aphron Drilling Fluid
BDF	Base Drilling Fluid
ROP	Rate of Penetration
AV	Apparent Viscosity
PV	Plastic Viscosity
YP	Yield Point
GS	Gel Strength
ppg	pound per gallon
ft	foot
API	American Petroleum Institute
W/V	weight / volume
HP	Hydrostatic pressure
ρ	Density
h	Highest
Ib/ bbl	bound/barrel
gm/cc	gram/cubic centimeter
cp	centipoise
ml	milliliter
°C	Celsius degree
mm	millimeter
m	meter

Author Contributions Statement: Waleed K. Mutter contributed to the Conception; Methodology; Investigation and Experiments; Data Analysis and Interpretation; Writing – Original Draft; and Writing – Review & Editing. Faleh H. Mohammed contributed to Methodology; Data Analysis and Interpretation; Writing – Review & Editing. Maryam M. Ahmed contributed to the Conception; Data Analysis; Literature Review. All authors have read and approved the final version of the manuscript.

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