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Investigation of The Effect of Temperature and Contamination on Properties of Saturated Salt-Base mud

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Abstract

The most difficult challenge that can be encountered when drilling a salt section is the difficulty of controlling the change in drilling fluid properties. In addition, the challenging geological environment was encountered. , creep behavior, slim hole drilling in salt formation have a few traits: high soluble, wash out salt section (1). The treatment did by using drilling mud that inhibits changes and is resistant to contaminants. Sodium chloride and potassium chloride brine were used to create a new mud for discussing this research, following up on changes in the properties of the new mud, simulating the conditions of Salt section (12.25" hole) in the Noor oil field. Moreover, In this investigation studied the effect of temperature and contaminants such as salt, shale and anhydrite on new mud properties (Rheological properties, Filtration, PH with Different concentrations of Kcl & Nacl. The results indicate that the dissolution of salt formation decreases with increasing KCl concentration up to 5% for saturating NaCl salt. This reduces the contaminant impact and increases the stability of mud characteristics.

Keywords: Saturated salt mud, salt formation, Binary brine, salt formation problems

تقصي أثر درجة الحرارة والتلوث على خواص ملح البسمود المشبع

الخلاصة:

إن أصعب التحديات التي يمكن مواجهتها عند حفر التجويف الملحي هي صعوبة التحكم في التغييرات على خصائص مائع الحفر، أيضًا في مواجهة البيئة الجيولوجية المعقدة، طبيعة زحف الملح، صعوبة المحافظة على سلامة جدار البئر، الذوبان العالي للملح، تأكل جدار الملح، وتتم المعالجة باستخدام طين الحفر الذي يكبح التغيرات ومقاوم للملوثات، وقد تم تقديم البحث بتصميم طين جديد باستخدام محلول ملحي ثنائي يتكون من كلوريد الصوديوم وكلوريد البوتاسيوم، ومتابعة التغيرات في خصائص الطين الجديد، الذي يحاكي ظروف المقطع الملحي (قطر 12.25 بوصة) في حقل نور النفطي، وكذلك يدرس هذا البحث تأثير الملوثات مثل الملح والطفل والأنهايدرايت على خصائص الطين الجديدة (الخواص الريولوجية، الترشيح، دليل

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القلوية) بتركيزات مختلفة من KCl & NaCl أظهرت النتائج أن انحلال تكوين الملح يتناقص مع زيادة البوتاسيوم حتى 5٪ مع الملح المشبع من كلوريد الصوديوم مما يؤدي إلى تقليل تأثير التلوث ويعطي المزيد من الاستقرار لخصائص الطين.

1. Introduction:

The first rule in drilling operations must be to study expected drilling problems before making the decision to drill in order to reduce drilling time and costs.

No well is drilled without problems; most of these problems suspend the drilling operations. Thus, understanding problems and analysis causes help us to avoid problems or reduce the risk of problems, there are many factors have to be considered in planning the well to avoid drilling problems. Subsurface pressure, lithology type (pore pressure, facture pressure, overburden pressure), depth, temperature, location, etc. [1]

During drilling operations, one or more of several factors can cause wellbore instability. This instability can manifest itself as caving, a tight hole, or hole erosion. Poor hole cleaning is one of the consequences, which can also lead to packing off, stuck pipe, and ultimately sidetracks. Other consequences include inefficient perforating, poor mud condition, difficulties running casing in and out of the hole, and poor quality cementing and logs. [2]

Before action can be taken to improve stability, it is of the utmost relevance that the problem formations and the mechanisms of instability be located. Once the causes are understood, it is possible to make an informed decision about how well planning, drilling procedures, and drilling fluid formulas might be improved to reduce problems and costs. The effect of temperature on salt solubility makes it difficult to maintain such a supersaturated system. [3]

The main objective of this study is to investigate the problems of drilling of abnormal salt section in Noor field and proposed a treatment; the current method is to analyze lithology, salt compositions, and detect overpressure zones, followed by an experimental investigation of the effects of lithology contamination (salt, anhydrite, and shale) on mixed salt mud system.

2. Study Area:

Noor oilfield is located in Mesopotamia Basin, these wells drilled through Tertiary period defiantly at Upper Fars which is mainly consist of sand and clay, 1680m thickness; Lower Fars is mainly consist of shale, about 670m thickness, Figure (1). There are complex problems such as overflow, leakage, borehole collapse, blocking in drilled well in Noor oilfield. High-pressure

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overflow phenomenon has found in Lower Fars salt inclusion shale rock, accompanied by shrinking phenomenon. Under the Lower Fars carbonated salt strata has leakage phenomenon, with shale shrinking phenomenon.

There is a creep property of the salt rock in Lower Fars layer· [4] It will increase the hole Shrinkage and the risk of casing damage. Creep deformation under the effect of geo-stress, with the deformation capacity related to a number of factors of which the most influential one is the temperature gradient. [5]

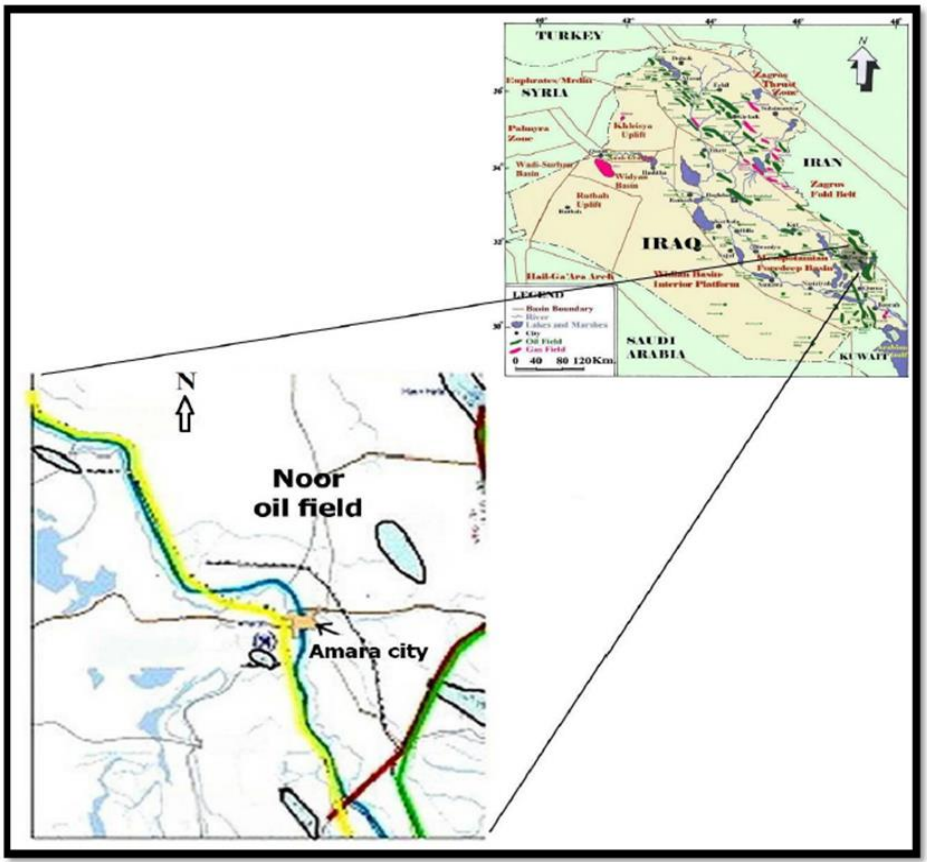

Fig. (1): Map of Noor Field [4]

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Analysis of chemical components of salt formation.

According to laboratory Analysis of core of salt in lower Fars, the result of analysis shown in Table (1).

Table (1) Analysis of Chemical Component

Item	Content of components	%
1	$CaCl_2$	13.55
2	$NaCl_2$	37.41
3	KCl	1.22
4	Na_2So_4	16.61
5	$SrCl_2$	1.33
6	$MgCo_3$	2.48
7	$SrCO_3$	0.06
8	$CaCo_3$	0.09
9	Impurities	27.25

Table (1) shows that the highest percentages of soluble rock chloride is 53.51 percent, sodium sulphate is 16.6 percent, and carbonate is 2.63 percent.

3. Methodology

3.1 Mud Materials

Bentonite should have been pre-hydrated in drill water (freshwater) with chlorides that had been treated with soda ash to reduce free calcium to 200 mg/l. This ensures that the Pre-Hydrated Bentonite yields properly and avoids overuse of the product and additional costs. After adding the Bentonite, the pH should be adjusted to 10.0 with Caustic soda to ensure that enough Bentonite can be added to the original make up water. Before dilution or use, this process should be pre-hydrated for at least 8 hours with the agitators running, Table (2).

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Table (2) Principal additives of salt saturated muds

No	Treating Agent		Function	Dosage (gm/350cc W.)
1	Rehydrated	Caustic Soda	pH Control	1
2		Soda Ash	Hardness Control (Mg^{2+} & Ca^{2+})	1
3		Bentonite	Viscosifier	22.5
	Rehydrated		Viscosifier	16%
4	Starch		Filtration loss control	9
5	Sodium Chloride (NaCl)		Weight & Saturated Brine	109
6	Ferro chrome lignosulfonate		Thinner	1.5
7	C-lignite		Thermal stability	1.5
8	Barite		Weighting up agent	As required
9	potassium Chloride (KCl)		Inhibitor & Brine	3% , %5 , 7%

3.2 The laboratory Apparatus.

Various laboratory instruments [6] for determining rheological properties, fluid loss, and density. Figures (2) through (5) depict these apparatuses. All of these tests were conducted at the Maysan Oil Company's laboratory.

Fig. (2): Chandler Engineering Model 1200 Atmospheric Consistometer

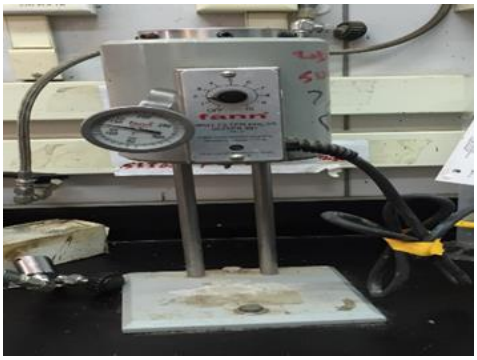

Fig. (3): High Pressure High temperature filter

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Fig. (4): Viscometer Chandler model 3500

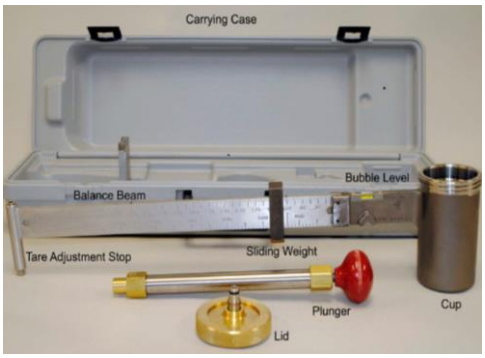

Fig. (5): Mud Balance pressurized

4. Drilling mud Design

The objective of these tests was to determine the solubility of different concentration of KCl with Saturated salt mud using contaminative lithology from lower Fars Formation with different temperature.

4.1 Rheological Parameters

26 samples of saturated salt muds were analyzed to determine the effects of temperature and various contaminants (Anhydrite, Shale, and Salt) on the temperature of binary salt mud.

The effect of Temperature on salt mud treated with various concentrations of KCl Solution is showed in Figure (6). As seen in the graph, temperature has a slight effect on the viscosity of plastic, the concentration of KCl increased, and there was a rapid increase in PV values after the addition of 5 percent KCl.

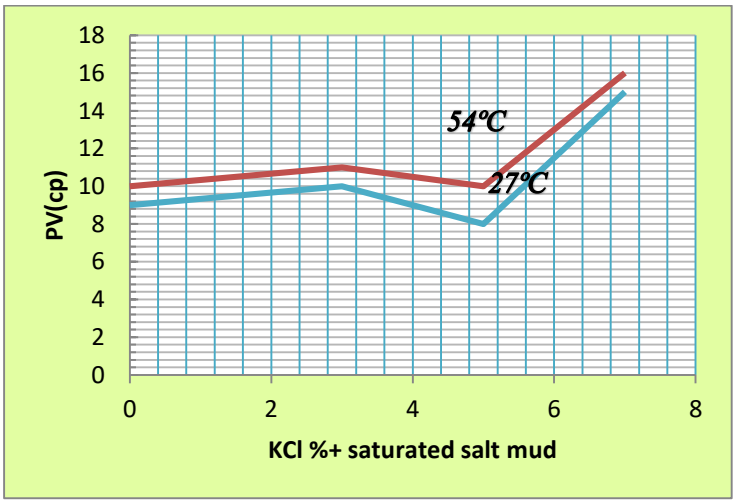

Fig. (6): Relation between Plastic viscosity and concentration of KCl

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While yield point decreases with saturated salt mud, it rises gradually with the addition of KCl until 7 % yield point remains the same at both temperatures, as depicted in Figure (7).

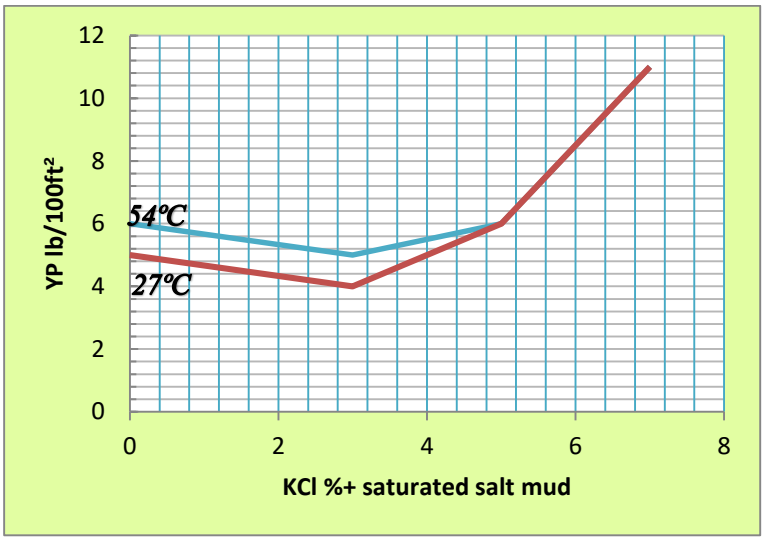

Fig. (7): Relation between yield point and concentration of KCl

4.2 Effect contaminators on Saturated salt muds.

In the following sections, the effect of contaminants such as salt, anhydrite, and shale on the rheological properties of saturated salt muds will be discussed.

4.2.1 Saturated salt mud

As salt formation in Lower fars consists of various types of salt due to salt formation dissolving in saturated salt mud, plastic viscosity and yield point are decreased. Ca^{++} ion trend to replace sodium ion in bentonite and flocculate the mud causes decrease Plastic viscosity and increase yield point as shown in Figure (8).

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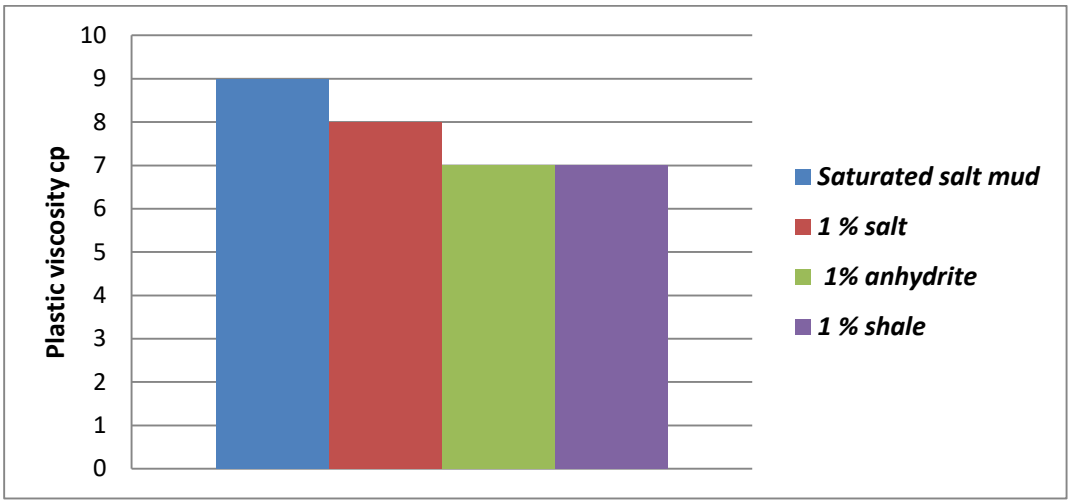

Fig (8) Plastic viscosity of saturated salt mud after exposure to various contaminants

The saturated salt mud is a strong inhibitor of shale, so the effect of shale on the saturated salt mud parameters is minimal, as shown in Figure (9).

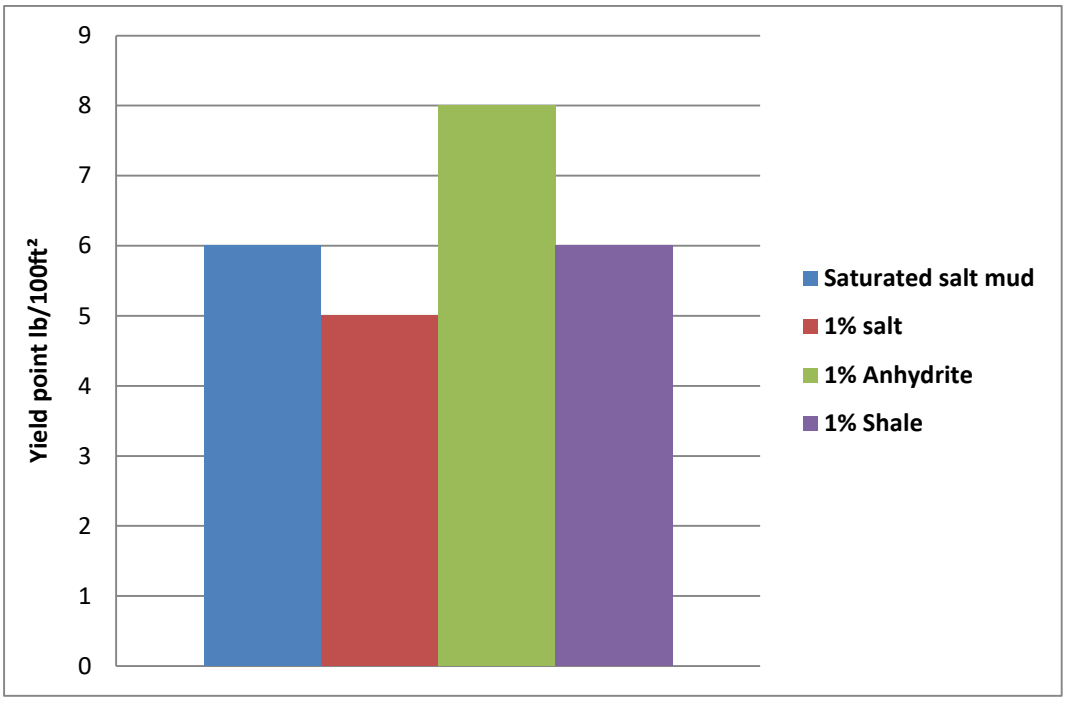

Fig. (9): Yield point of saturated salt mud after exposure to various contaminants

4.2.2 Saturated salt mud with three percent KCl

Salt contaminator shows the major increase while the shale and Anhydrite have the same level in Plastic viscosity value smaller than salt as shown in Figure (10), which depicts the effect of 1

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percent Concentration of contaminators (Salt, Anhydrite and shale) on Rheological properties of salt saturated mud that was treated with 3 % Kcl solution as shown in Figure (11).

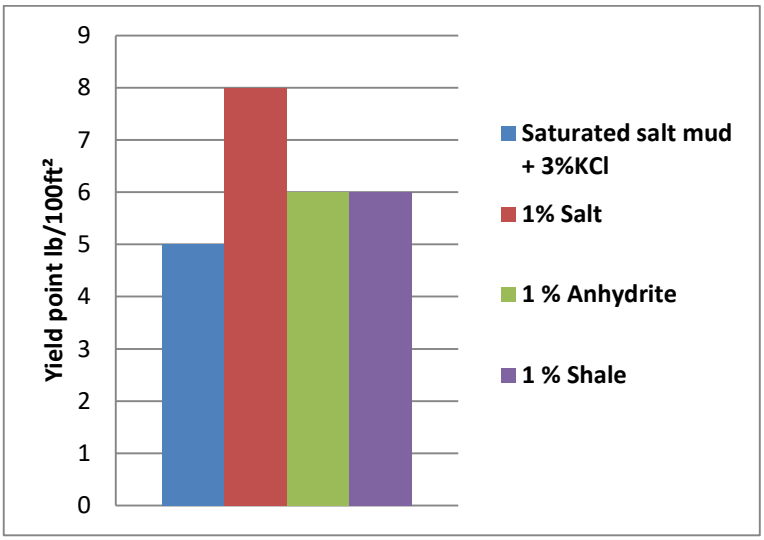

Fig. (10): Yield point of saturated salt mud with three percent KCl after exposure to various contaminants

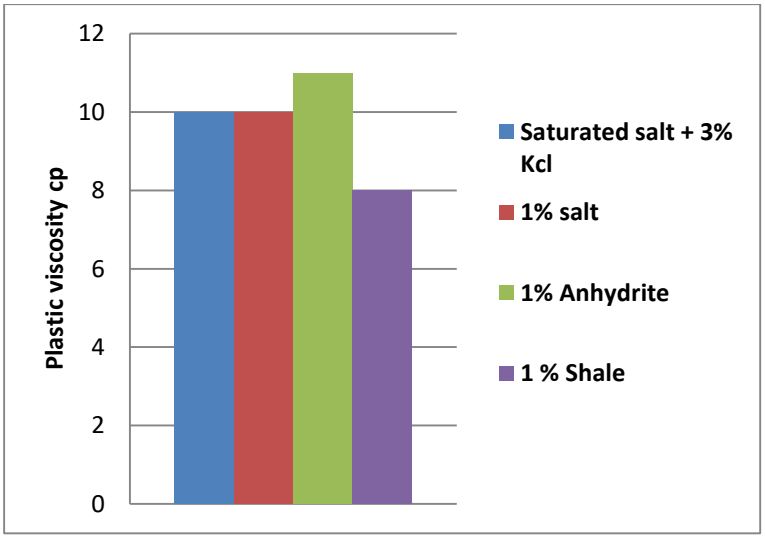

Fig. (11): Plastic viscosity of saturated salt mud with three percent KCl after exposure to various contaminants

4.2.3 Saturated salt mud +5%Kcl

Due to its high resistance to contamination, saturated salt mud +5% Kcl samples behave slightly differently from those of other types; however, there are no significant changes in the viscosity of the plastic observed in Figure (12).

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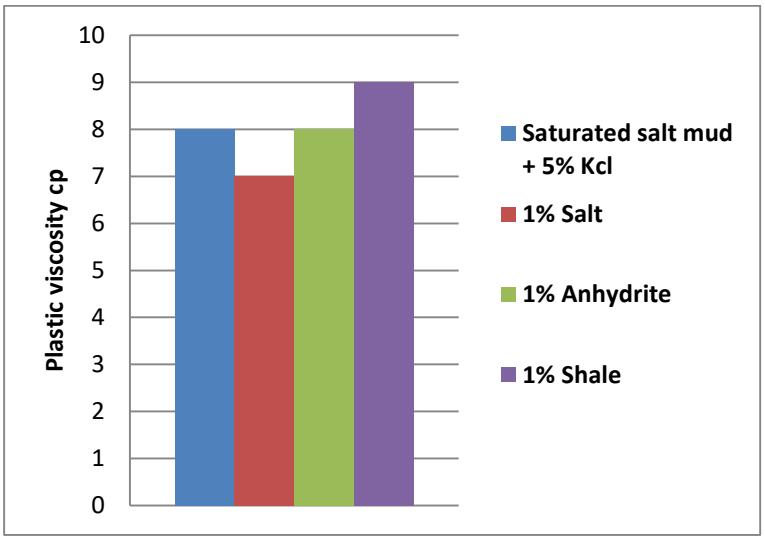

Fig. (12): Plastic viscosity of saturated salt mud with 5% KCl after exposure to various contaminants

In addition, the effect of contaminative is slight on yield point as shown Figure (13).

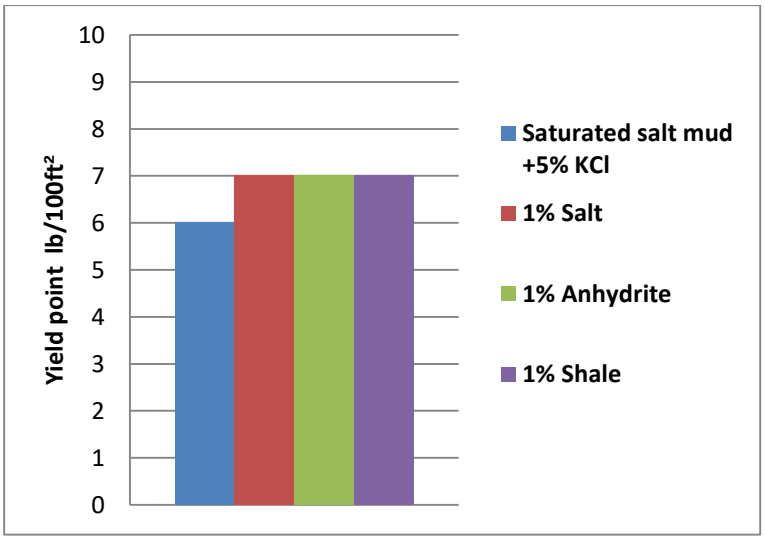

Fig. (13): Yield point of saturated salt mud with 5% KCl after exposure to various contaminants

To understand this phenomenon of rheological parameter effects (PV, Yp) for the saturated salt mud and KCl concentrations, this effect was attributed to the dispersive effect of salt, which can be either physical (by increasing the distance between particles) or chemical (by altering particle surface charge in such a way that particles repel each other).

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4.3 Rheological models

The Average Absolute Percentage Error method was used to determine best rheological model that fit the saturated salt muds. For these saturated salt muds, the best model can be shown in Table (3), where it has the closest value to one.

Table (3) Rheological models of drilling fluid

Model	S.S.M.	S.S.M.+3%KCl	S.S.M.+3%KCl
Bingham Plastic	1.672	1.511	2.509
Power law	3.814	3.516	2.953
Modified power law	-	-	-
Casson	7.504	8.286	7.271

The Bingham Plastic model is nearest model to samples of drilling fluids as shown in Figure (14).

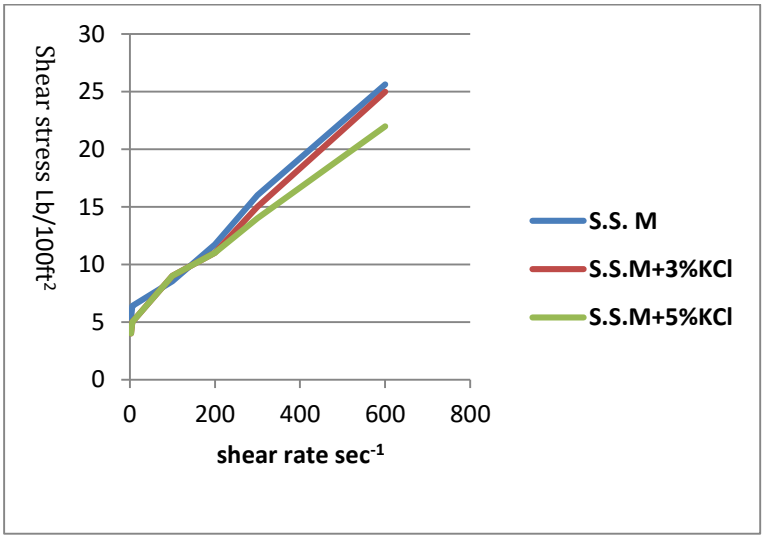

Fig. (14): Shear stress vs. shear rate for saturated salt mud.

4.4 Filtration

Filtration rate affects the stability of the wellbore walls, which are subject to softening and degradation by aqueous filtrate. [7]

Salt saturated with or without KCl used to examine the impacts of contaminants on Filtration, Filtration with salt contaminant had the highest value of Filtration while less influence on shale contamination, In the same way, KCl 3 percent has the same effect. Finally, slight effect of contaminants on KCl 5%.

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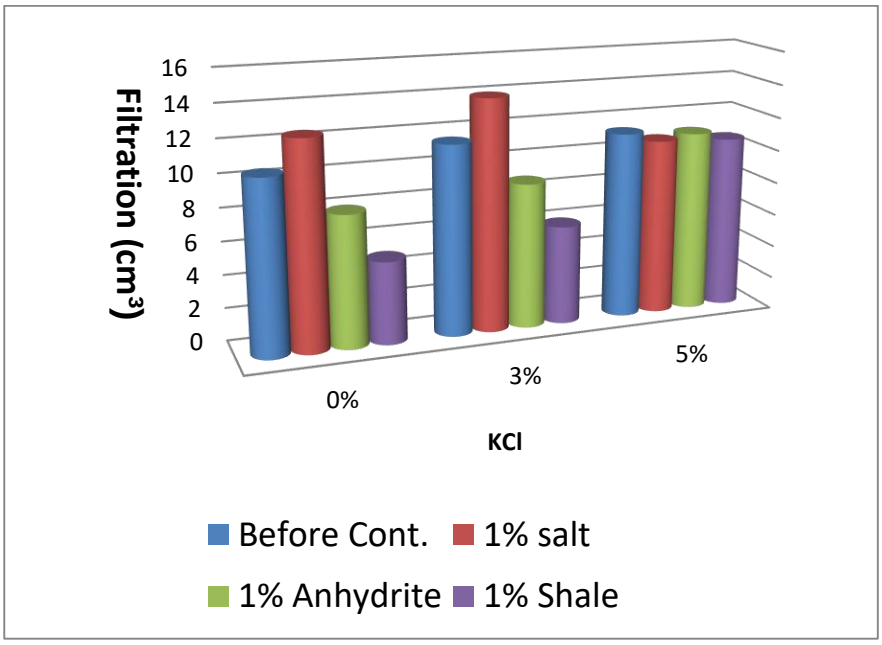

Fig. (15) Effects of The Contaminants on Filtration of Saturated salt mud with different concentrations of KCl.

4.5 Density

Density is particularly significant when drilling abnormal pressure, the fluid must be able to carry the mud weight necessary to control the well, and circulation, surge, and swab pressures must not be excessive. [8] Equivalent mud weight affects density, therefore salt drilling is the most challenging. A high pore pressure salt layer and easy sticking and overflow are seen in the third section (12 1/4") of the pipe. High mud density is needed for abnormal high-pressure section to balance formation pressure; however high density will increase the risk of lost circulation.

During the drilling process, care must be taken to avoid the well kick and leaks. Therefore, the recommended mud density is 2.21 to 2.25 g/cm3. To avoid drilling sticking, reaming should be done on a regular basis.

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5. Conclusion

1- The results of the mud drilling experiment show that raising KCl to 5% reduces salt formation dissolution, resulting in a smaller contaminative effect and greater mud quality stability.

2- Due to the incomplete dissolution of 7 percent KCL at 54 degrees Celsius, samples of saturated salt mud containing 7 percent KCL were excluded from testing.

3- Chrome lignite added to saturated salt mud in a downhole condition reduces the high temperature's effect (54^{o}C).

4- Measuring the PH of contaminated salt mud made reading PH paper difficult.

5- During salt formation drilling, filtration values go up because of contamination. When salt is handled poorly, it causes starch to be treated too much, which leads to high ca++ and high temperature, in addition to low PH, this leads to thick, high-density mud, This may result in drilling operations being stopped and mud being difficult to repair.

6- Bingham Plastics' rheological model may be used to represent drilling salt with different amounts of KCl.

7- In the salt section, a salt-saturated mud solution with 26% NaCl and 5% KCL will be used to inhibit shale and get the necessary mud weight with the least particles. This will make it easy to run the 9 5/8" casing and cement it without any problems.

8- The optimum mud density of saturated salt mud is (2.21-2.25) gm/cc.

9- It is important to use a PH meter during the drilling salt section to avoid over treatment of caustic soda. The pH will be maintained at the 9-to-10 range; it will be regulated using caustic soda. This improves polymer performance and reduces clay dispersion.

10- Using a 5 percent KCL concentration with saturated salt mud is optimul for mud enhancement and improving saturated salt mud performance.

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