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Investigative Study of the Properties of Low Solid Drilling Fluid Prepared by Using Iraqi Bentonite

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Abstract

This study aims to investigate the properties of drilling fluids with low solids content prepared using Iraqi bentonite. Polyacrylamide polymer, sodium polyacrylate polymer, Nano silica, and fine silica were used, as the results demonstrated the success of these materials in preparing drilling fluids with low solids content. As for micro silica, it is a material used with cement, but it was used in this study with drilling fluids because it is cheap in addition to being an environmentally friendly material. Polyacrylamide is a highly absorbent and effective material, which is usually used during well injection, but in this study it was used to improve the properties of Iraqi bentonite. 10 samples of drilling mud were prepared using the aforementioned materials in different proportions, and Iraqi bentonite was also used as a dispersant or dispersant phase. The percentage of bentonite during preparation ranged between (1.5-5) % in order to achieve sufficient gel resistance and balance the filtration speed. By drawing the relationship between shear stress and shear rate, it was found that all prepared samples follow the power law model, as this was used in hydraulic calculations in order to determine the pressure loss in the hydraulic system of the well. The results show that polyacrylamide polymer has the best effect on Iraqi bentonite among the other used materials in this study, where 1% from this material is enough to enhance properties (rheology and filtration) of Iraq bentonite. However, it has been observed from the laboratory results that when the percentage of bentonite is reduced to 1.5%, the prepared liquid will fail to suspend the barite and therefore will not achieve the required density in spite of the addition of barite. The best sample for the drilling fluid is when the percentage of the total solid is 5%, i.e. (10 gm Iraqi bentonite, 7 gm barite, 1 gm polymeric, Nano, or nanomaterials). As this drilling fluid had the best performance in terms of pressure loss, as they gave the least pressure loss.

Keywords: drilling fluid, properties, solid, polymer, Nano.

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دراسة بحثية لخصائص سوائل الحفر ذات الصلابة المنخفضة المحضرة باستخدام البنتونايت العراقي

الخلاصة:

يهدف هذا البحث إلى دراسة خواص سوائل الحفر ذات المحتوى الصلب المنخفض المحضرة باستخدام البنتونايت العراقي. تم استخدام مستحلب البولي أكريلاميد، ومستحلب البولي أكريلات الصوديوم، والنانو سيليكا، والمايكرو سيليكا، حيث أظهرت النتائج نجاح هذه المواد في تحضير سوائل الحفر ذات المحتوى الصلب المنخفض. أما بالنسبة للمايكرو سيليكا، فهي مادة تستخدم مع الأسمنت عادةً، ولكن تم استخدامها في هذه الدراسة مع سوائل الحفر لرخص تكلفتها بالاضافة الى كونها مادة صديقة للبيئة. مادة البولي اكريلاميد هي مادة عالية الامتصاص وفعالة، تستخدم عادة أثناء حقن الآبار، ولكن في هذه الدراسة تم استخدامها لتحسين خواص البنتونايت العراقي.

تم تحضير 10 عينات من سوائل الحفر باستخدام المواد المذكورة أعلاه بنسب مختلفة، وتم استخدام البنتونيت العراقي أيضًا كمشتت أو مرحلة مشتتة. وكانت نسبة البنتونيت أثناء التحضير تتراوح بين (1.5-5) % لتحقيق مقاومة الجل الكافية وتوازن سرعة الترشيح. وعند رسم العلاقة بين إجهاد الانزلاق ومعدل الانزلاق وجد أن جميع العينات المحضرة تتبع نموذج قانون القدرة، حيث تم استخدامه في الحسابات الهيدروليكية من أجل تحديد فقدان الضغط في النظام الهيدروليكي للبئر. أظهرت النتائج أن بوليمر بولي أكريلاميد له التأثير الأفضل على البنتونايت العراقي من بين المواد الأخرى المستخدمة في هذه الدراسة، حيث أن 1% من هذه المادة كافية لتعزيز الخواص (الريولوجية والترشيح) للبنتونايت العراقي. ولكن لوحظ من النتائج المختبرية أنه عند تخفيض نسبة البنتونيت إلى 1.5% فإن السائل المحضر لن يتمكن من تعليق الباريت وبالتالي لن يحقق الكثافة المطلوبة بالرغم من إضافة الباريت. أفضل عينة لمائع الحفر هي عندما تكون نسبة المادة الصلبة الكلية 5% أي (10 غم بنتونايت عراقي، 7 غم باريت، 1 غم بوليمر، نانو، أو مواد نانوية). حيث أن سائل الحفر هذا كان له أفضل أداء من حيث فقدان الضغط، حيث أنه أعطى أقل فقدان للضغط.

1. Introduction:

The main function of the drilling fluid consisting of (water and clay) is to displace the drilled rocks [1]. It is practically found that the drilling speed increases when the amount of solids in the drilling fluid decreases, and thus the apparent viscosity decreases [2]. Therefore, it is better to use drilling fluids with a low solid content, such as polymeric drilling fluids [3]. Oil and water are in some cases ideal drilling fluids for drilling the ground layers with low pressure [4]. Low solids drilling mud is a drilling fluid that contains less solids than conventional mud with the same density and parallel use [5]. The low solids drilling fluid strategy and maintenance is mainly implemented by substituting one or more polymers for ordinary bentonite [6]. Polymers are materials with a specific repetitive molecular structure attached to each other forming a long chain [7]. The components of the mud rely on the functions that should be performed through the drilling operations [8]. Drilling fluid containing little solids or so called low solid mud such as, oil in aqueous solution, brine with starch, non-saline water with bentonite, CMC, polymer [9]. After the great progress in drilling technology, drilling fluids are no longer composed of clay and water only. Rather, it is a mixture of liquids, solids, and chemicals in order to perform different drilling functions and conditions [10]. In 1953 there is change on the low solid mud definition depending

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on the maximum permit concentration (4-7) %, but lacus ,1968 considered that the appropriate bentonite concentration is (1.5-2) %, which is enough to achieve good gel strength and good rate of penetration [11].The drilling speed increases whenever the hydrostatic pressure of the drilling fluid column decreases as a result of a decrease in its density, as well as whenever the filtration speed increases in front of the drilling rig [12]. (But it must contain a lower content of solids) and have sufficient viscosity to remove the drilled rock pieces, and have a low filtration so as not to affect the stability of the well wall [13]. It is difficult to isolate the effect of solids content on penetration rate from the effect of drill bit density [14]. The higher solid content, the higher the density of the drilling mud, so both effects are present in drilling operations [15]. To study the effect of the solid content on the rate of penetration, field tests were carried out using water and drilling mud with a density of 9.2 ppg [16]. It was found that the rates of penetration using water were very high [17]. Among the most important chemicals used in preserving slurries with low solids content are polymers and salts [18]. Dextride polymer is the best type for obtaining maximum volume for lifting crumbs, while XC is the best type of polymer for obtaining high viscosity in the annular space [19]. Table (1) illustrates the Previous studies that related to the subject of the study (low-solid drilling fluid). The aim of this research is to shed light on the most important properties (rheology and hydraulic) of drilling fluids with low solid content and to compare them with other similar fluids. And the other aim of this study is to enhance the properties and activation Iraqi bentonite using active materials in order to preparing low solid drilling fluid.

Table (1) Previous studies that related to the subject of the study (low-solid drilling fluid).

Authors	**Year**	**Findings, study, technique, method or model**
Iscan and Kok	2007	They investigated that the high solid content in the drilling mud affects its properties and leads to uncertainty in the well bottom condition. It ultimately contributes to poor drilling rig performance and an increase in operating cost [20].
Dolz et.al	2007	They founded that hole cleaning can be improved with low solids content drilling muds with low gel strength and low viscosity within shear rates subjected to annular flow [21].
Shakib et.al	2016	They concluded that higher solids content can eventually increase the density and viscosity of clay. In future, it may expose the well to high contamination of mud properties. In addition, large horsepower is required for crushing the gel and pumping the mud for circulation [22].

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Sadegh et.al	2016	They found that it becomes difficult to control the rheology and filtration properties when the solids concentration becomes excessive. High particulate solids reduce penetration rate due to increased mud density and viscosity. The higher the density of the mud, the greater differential pressure. ROP decrease when the value of differential pressure increase [23]
Assi et.al	2018	Founded that the using of Xanthan gum enhance Iraqi bentonite properties and they suggested to use this polymer to prepare low solid drilling mud [24]
Brito et.al	2018	In their work, they formulated two low solid low-solid nondispersed (LSND) clays: carboxymethylcellulose (CMC)-LSND clay and partially hydrolyzed polyacrylamide (PHPA)-LSND clay. A qualified analysis was performed for evaluating improvements to their properties. LSND clays help maintain mud stability and proper cuttings removal. The results of their work show that the addition of both CMC and PHPA helps for improving the mud properties; However, PHPA-LSND clay was established to be the superior [25]
Faleh and Batool	2021	They used simulations to approve that the technique of management pressure drilling (MPD) is so important to maintain equivalent circulation density , they founded that the MPD technique allowing to choose the properties of drilling mud [26].

2. Materials and Methods:

Drilling mud is a colloidal solution consisting of more than one material such as bentonite and other chemicals. It has certain properties it can be controlled such as density, viscosity, viscosity, acidity (PH) which is expressed in degree Positive hydrogen ion concentration + H, Alkalinity expressed by negative hydroxyl ion concentration and filtration.

2.1 Prepare mud samples:

Inspection and preparation of mud samples were according to the American Petroleum Institute (API) standard. 22.5 grams of Iraqi bentonite from the Akashat region was used as in Figure (1) with 350 cubic centimeters of water, and this was the basic model to which the materials used in the study were added. The samples were kept for 24 hours for hydration, and then measurements such as density, filtration, viscosity, and alkalinity were taken. And the rest of the samples were prepared from bentonite at a ratio of (1.5-3) % and different percentages of polyacrylamide, sodium polyacrylate, and silicon polymers started from (0.2% to 0.5%), as illustrated in Table (2).

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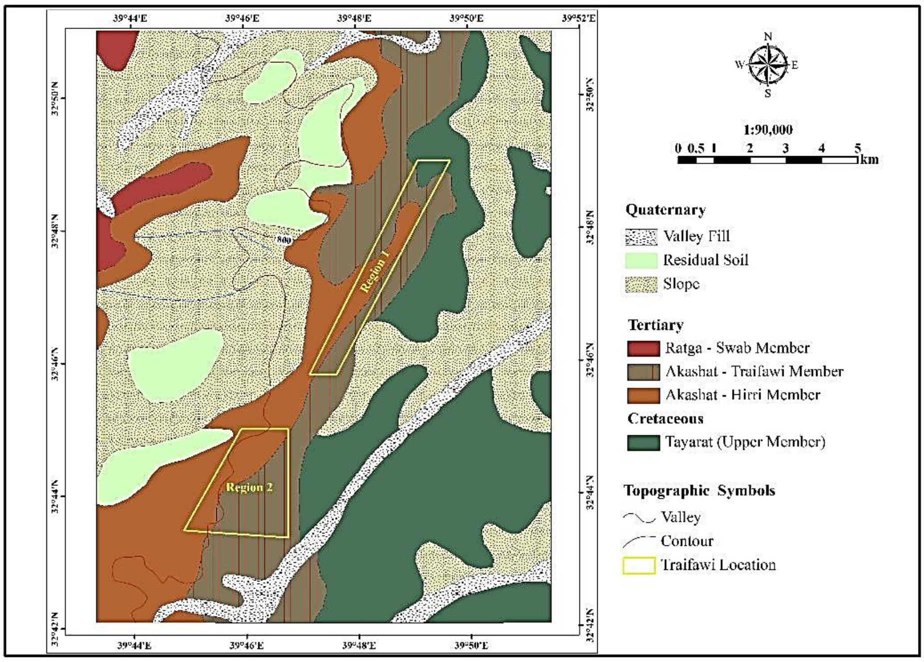

Fig. (1): Akashat area (the area from which the used bentonite was taken) [27]

Table (2) Materials used in experiments and its quantities

Samples	Water (cc)	Material and quantities
1	350	22.5 gm Iraqi Bentonite (Base)+ 5gm barite
2	350	22.5 gm commercial Bentonite + 5gm barite
3	350	10gm gm Iraqi Bentonite + 1 gm Nano silica +7gm barite
4	350	10 gm Iraqi Bentonite + 1gm micro silica+7gm barite
5	350	10 gm Iraqi Bentonite + 1 gm polyacrylamide+7gm barite
6	350	10 gm Iraqi Bentonite+ 1gm sodiumpolacralyte+ 7gm barite
7	350	5 gm Iraqi Bentonite + 1.5 cc sodiumpolacralyte +10gm barite
8	350	5 gm Iraqi Bentonite + 1.5 gm micro silica+10gm barite
9	350	5 gm Iraqi Bentonite + 1.5 gm polyacrylamide+10gm barite
10	350	5 gm Iraqi Bentonite + 1.5 gm Nano silica +10gm barite

2.2 Bentonite Beneficiation:

Enrichment is the improvement of low quality clay by adding chemicals for it. The properties of Iraqi bentonite have been improved by adding polymers, to improve rheological properties, filtration and pH values, respectively. Developing mud with a low solid content is desired for easier fluid maintenance, better solid control, quicker penetration rate, and better hydraulics in oil

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wells. In this effort, low solid mud was prepared by substituting a certain quantity of bentonite in traditional mud with a small quantity of polymers.

2.3. Used materials: The following are the most important materials that were used in the study. Figure (2) shows these materials.

2.3.1. Iraqi bentonite: In this effort, the Iraqi bentonite is used as dispersed phase. The sample taken from the Al-Anbar / Akashat area. The investigates for Iraqi bentonite and commercial bentonite are illustrated in Table (3).

The standard Philips model PW1877 computerized powder diffractometer with Cu-Kα radioactivity and silicon powder was used as a model to detect the composition and diffraction pattern of Iraqi bentonite and the samples in the study.

2.3.2. Commercial Bentonite: the commercial bentonite that used in this study is Calcium Bentonite (BCa). It's a white powder with a fine, soft texture. It is an impure clay composed primarily from montmorillonite. The boiling point of this bentonite is 381.8 ° C and its original manufacturing from China.

2.3.3. Polyacrylamide: Polyacrylamide has the structural formula CH2CHCONH2(n) and has wide uses, including in the treatment of dispersion water for sediments or calcifications, in the paper industry and as thickeners, in the oil industry, in the treatment of well soil, in the mining industries, in agricultural applications as a soil stabilizer, in increasing the efficiency of pumping water for extinguishing fires, and in the manufacture of adhesives. Polyacrylamide is odorless, solid, with a glassy white color, with low toxicity. It dissolves in water, formaldehyde and ethylene glycol. It decomposes in the presence of water in an acidic medium 405, as well as in an acidic and basic environment. Polyacrylamide can be prepared by radical chain-growth polymerization or ionic polymerization and the used initiator K2S2O8. The polymerization process requires pure monomer [28].

2.3.4. Nano silica: Nano silica is an inorganic chemical material, commonly known as white carbon black. Because the size of Nano silica is very small, it is between 1 and 100 nanometers thick, so it has many unique properties, such as having optical properties against ultraviolet radiation, and improving the capabilities of other materials against

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aging, strength, and chemical resistance. Silica has various applications. Silica nanoparticles is a white amorphous powder, non-toxic, tasteless, non-polluting, form into a spherical structure, showing quasi-molecular structure and succulence network, molecular formula and formula $SiO2$, insoluble in water [29].

2.3.5. Sodium polyacrylate ($C3H3NaO2$): is a super absorbent material, with a water absorption capacity of about 200 to 300 times its mass. The most important uses of sodium polyacrylate are baby diapers to prevent water leakage, and the more this substance is, the greater the ability of the diapers to absorb water. It is used to produce artificial snow. Sodium polyacrylate is an anionic polyelectrolyte with negatively charged carboxylic groups in the main chain. Sodium polyacrylate is a chemical polymer composed of chains of acrylate compounds. It contains sodium, which gives it the ability to absorb large amounts of water. Sodium polyacrylate is also classified as an anionic polyelectrolyte. When dissolved in water, it forms a thick, transparent solution due to the ionic interactions of the molecules. Sodium polyacrylate has many favorable mechanical properties. Some of these advantages include good mechanical stability, high heat resistance and strong wetting [30].

2.3.6. Silica fume, silica fume, also known as micro silica, is a by-product of the ferrosilicon metal production process in electric arc furnaces, as it is obtained from the smoke rising through the furnace stacks by the condensation process. Some specialists accepted Condensed Silica Fume (CSF). Silicon dioxide makes up about 90% of the composition of micro silica, and its particles are spherical in shape and ultra-fine, so that they are about 100 times softer than cement. Part of the cement materials used in the concrete mix can be replaced with micro silica in proportions ranging from 7-15% of its weight [30]. Micro silica is produced in Europe, Egypt, South Africa and India.

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Table (3) XRF analysis for the used samples

Elements	Iraqi bentonite only	Commercial bentonite only	Iraqi bentonite + 0.05% Nano silica	Iraqi bentonite + 0.5% polyacrylamide	Iraqi bentonite + 0.5% micro silica	Iraqi bentonite + 0.5% Sodium polyacrylate
sodium	2.27%	1.99800%	1.6870%	1.20000%	0.90200%	0.80200%
Magnesium	2.31%	1.97600%	1.6480%	1.20800%	0.65900%	0.55900%
Aluminum	15.15%	13.80000%	11.5600%	8.66500%	5.69800%	4.69800%
Silicon	52.21%	63.91000%	85.3600%	66.57000%	76.84000%	78.88000%
Phosphorus	0.22%	0.20920%	0.1777%	0.14200%	0.10000%	0.10000%
Sulfur	0.34%	0.78830%	1.1450%	1.53100%	2.71500%	2.81500%
Chlorine	0.23%	0.20830%	0.1799%	0.15310%	0.09922%	0.09822%
Potassium	0.20%	0.16570%	0.1351%	0.09140%	0.03890%	0.02890%
Calcium	2.20%	2.01000%	1.6620%	1.44500%	0.98330%	0.88330%
Titanium	2.02%	2.03200%	1.7410%	1.35500%	1.08800%	1.09800%
Vanadium	0.05%	0.05820%	0.0570%	0.05760%	0.06750%	0.06750%
Chromium	0.01%	0.01153%	0.0104%	0.00778%	0.00591%	0.00591%
Manganese	0.09%	0.08890%	0.0777%	0.06150%	0.04652%	0.04652%
Iron	14.00%	13.82000%	11.9300%	9.24700%	7.23200%	6.23200%
Cobalt	0.01%	0.01301%	0.0067%	0.00423%	0.00238%	0.00228%

Fig. (2): Used materials: a) polyacrylamide b) Iraqi bentonite c) Nano silica and d) sodium polyacrylate

3. Measurement Procedure:

Drilling fluids have several properties that are regularly checked during drilling operations for the purpose of prediction the changes that occur in these properties due to the impact of drilling fluids

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on the penetrating layers, which leads to a change in properties, as each of the properties of the drilling fluid is responsible for a specific function performed by these liquids. And field tests on them are necessary to assess their suitability for drilling and to match the properties with the properties Programmed and checks are usually according to API standard.

3.1 Balance: It was used to determine weights. The words "mass" and "weight" are often used interchangeably. Mass is one of the fundamental quantities in Physics and the most important properties of matter.

3. Mud Mixer: This device is used to mix the basic drilling mud components (water, bentonite and other additives) in order to prepare the final drilling mud. The HMD 200 Mixer as shown in the Figure (3) was used.

3.3. Mud Balance: One of the most important properties monitored throughout the drilling operation is the mud density. Mud weight or mud density is a weight of mud per unit volume. It is one of the most important drilling fluid properties because it controls formation pressure and it also helps wellbore stability. A conventional mud balance that was manufactured by OMCO (model 140) manufacturing in America normally measures mud weight. The mud balance is always calibrated with fresh water and it must give the reading of 8.33 ppg.

3.4. Fann viscometer: The device that are used to measure rheological properties is Viscometer 8 speed (model 800) manufacturing in America.

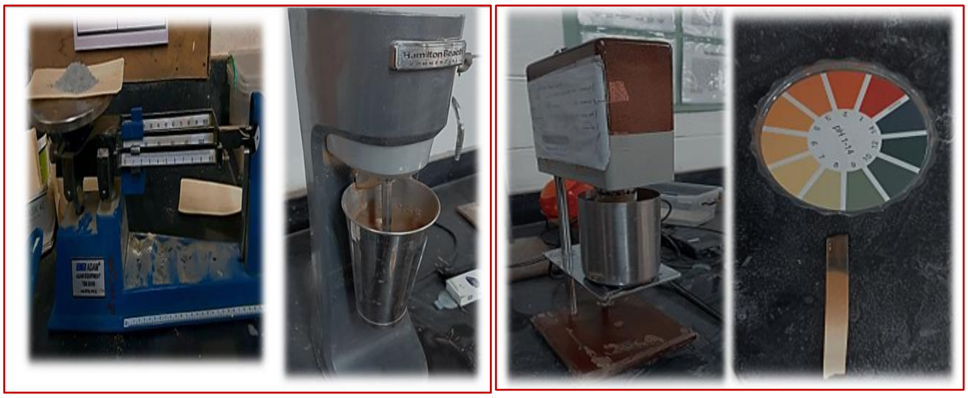

Fig. (3): Viscometer pH Paper, balance and mixer.

3.5. Dead Weight and Hydraulic Filter Press: The Dead Weight and Hydraulic Filter Press shown in the Figure (4) is one of Series 300 Filter Press equipped with a Dead Weight Hydraulic tool. Measurements of filtration behavior and wall cake-building characteristics

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of a drilling fluid are fundamental to control and treatment of drilling fluids, as are various characteristics of the filtrate such as oil, water, or emulsion content.

Fig. (4): Dead Weight Hydraulic tool.

4. Research Methodology:

Figure (5) is a diagram figure showing the research method, which started from preparing the clay and measuring its properties, then linking the practical side to theory using hydraulic equations and finding pressure loss. Also, Hydraulic Calculations with Excel is an easy-to-use tool specifically designed to help calculate pressure drop and flow characteristics. Since it is an Excel spreadsheet, entering data is all it does and let this tool do the rest by using equations from 1 to 10 as in Figure (6), Table (4) includes field data used in this study.

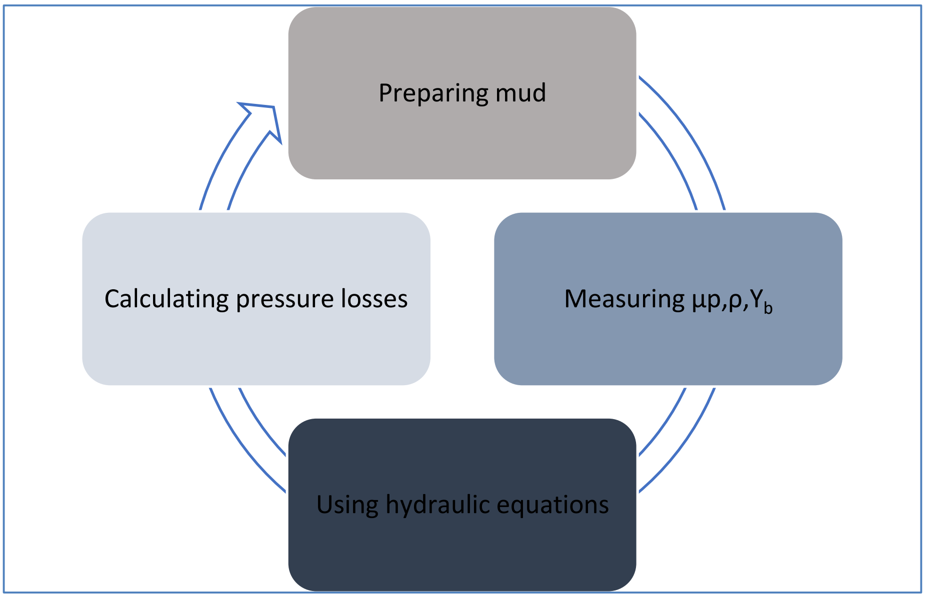

Fig. (5): Research methodology.

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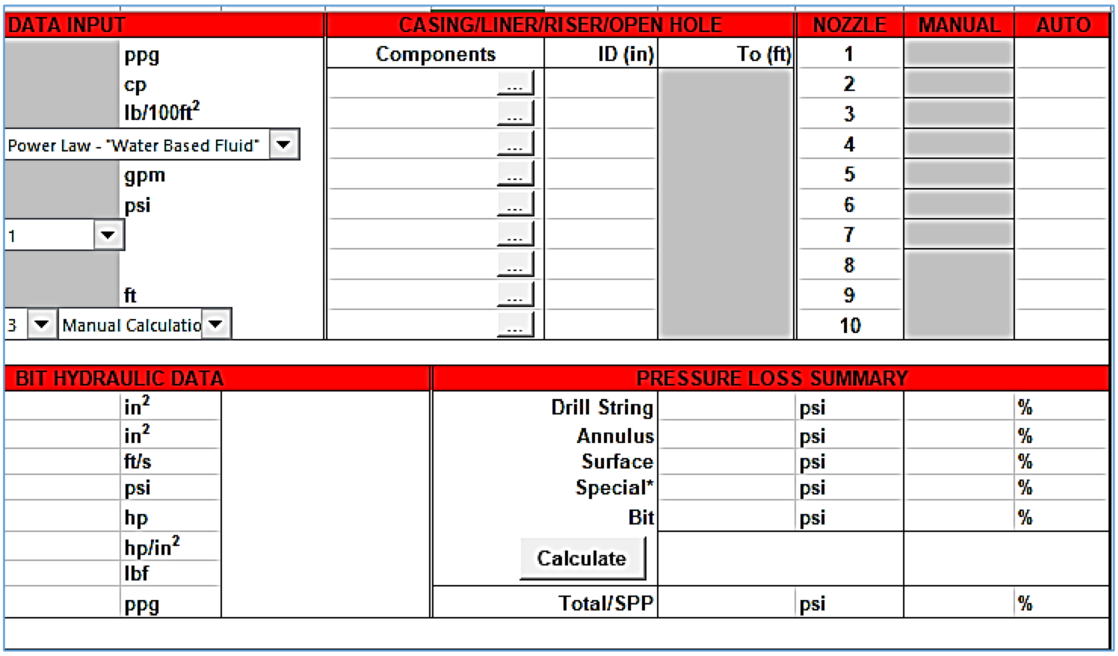

Fig. (6): Excel sheet hydraulic calculations.

Table (4): Field data

Depth	**5000 ft.**
Bit	8.5 inch
Drill pipe	4500 ft. , OD 4.5 inch
Drill collar	500 ft., OD 6 3/4 ID 2.385
Annular velocity	120 ft./min
mud density	10 ppg.

$$\mu p = \emptyset 600 - \emptyset 300 \quad \ldots 1$$

$$yp = \mu p - \emptyset 300 \quad \ldots 2$$

$$\mu a = \emptyset 600/2 \quad \ldots 3$$

$$v = 24.5 * \frac{Q}{dh2 - dp2} \quad \ldots 4$$

$$Re = \frac{\rho d v}{\mu} \quad \ldots 5$$

$$\Delta p2 = 8.91 * 10^{-5} * \rho^{0.8} * Q^{1.8} * \mu * P^{0.2} * \frac{L}{D^{4.8}} \quad \ldots 6$$

$$\Delta p3 = (8.91 * 10^{-5} * \rho^{0.8} * Q^{1.8} * \mu * P^{0.2} * L)/(Dh - Dp)^{3}(Dh + Dp)\text{^}1.8 \quad \ldots 7$$

$$\mu eff = 300 * \frac{\emptyset}{RPM} \quad \ldots 8$$

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$$Vc = \left[5.82 * 10^4 * \frac{K}{\rho}\right]^{\left(\frac{1}{2-n} * \left[\frac{1.6}{D} * 3n + \frac{1}{4n}\right)\right]^{\frac{n}{2}-n}} \quad \ldots 9$$

$$HP = Q\,\frac{\boldsymbol{\Delta PT}}{\mathbf{1714}} * 0.95 * 0.85 \quad \ldots 10$$

Where;

Va = Annular velocity, ft/min

Dh = Diameter of wellbore, inch

Do = Outside Diameter of tubular, inch

W = mud weight, ppg

µea = effective viscosity in the annulus, centi-poise

na = power law constant

Pb = pressure drop across a bit, psi

Q = flow rate, gpm

W = mud weight, ppg

A = total flow area, square inch

5. Results and Discussion:

The choice of drilling system and liquid usually begins according to the nature of the rock formation and consideration of its financial as well as environmental repercussions. As one of the most important factors in choosing a drilling fluid is good design, formation pressure, rock mechanics, logistics, environmental issues and regulations, and most importantly its cost. The drilling fluid must consist of five basic properties, which are rheology, fluid loss, chemical properties, solid contents, and density. Where solids can be high gravity such as barite and other weighting materials or low gravity such as polymers. The ten samples were examined by examining stability, where the third and fifth samples were the most stable, due to their composition of nano silica and polyacrylamide, since these two materials are highly absorbent of water. While the first sample showed the least stability, due to the fact that it is prepared from Iraqi bentonite only and water. As for samples from 7 to 10 only, they showed unacceptable stability, due to their failure to suspend barite, because their solid content was very low, 1%,as shown in Figure (7). Figure (8) shows the effect of the additions of the four materials used in the study on the plastic viscosity of Iraqi bentonite. Polyacrylamide showed the most effective and clear increase on the viscosity of the clay, due to the strong ability of this material to absorb water. Also,

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microsilica showed the least effect on the viscosity of the clay, due to its low ability to absorb water and rehydrate.

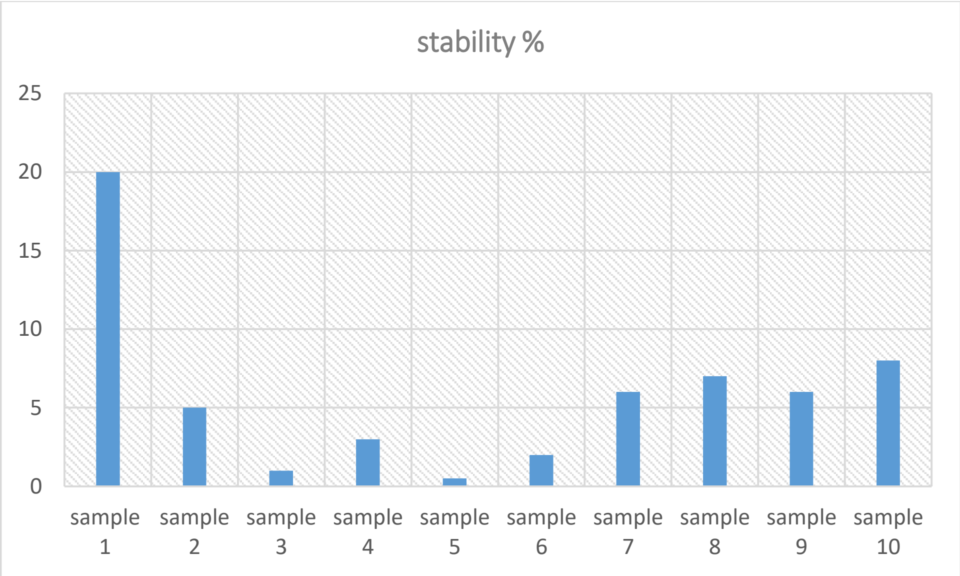

Fig. (7): Stability of the used samples

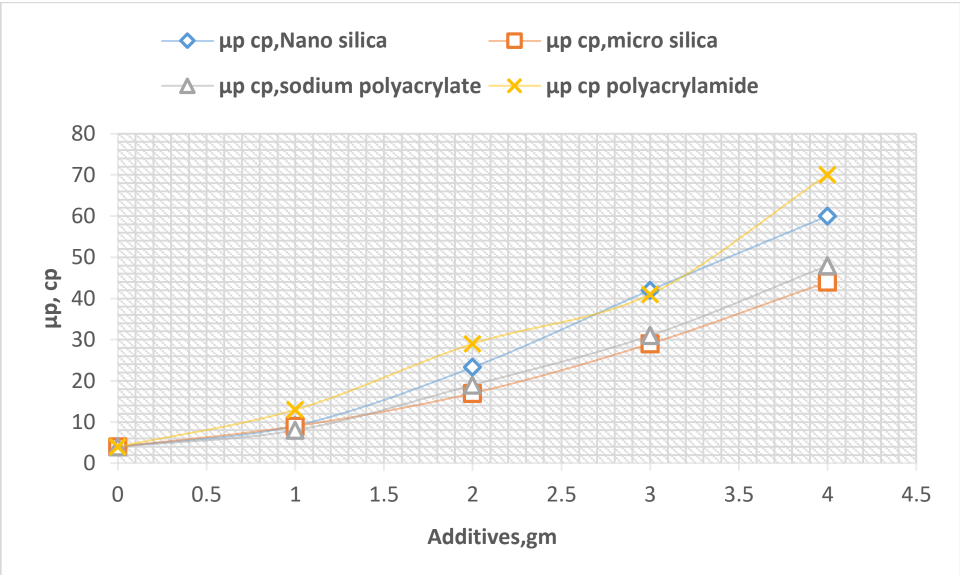

Fig. (8): Effect of the studied materials on mud viscosity

Figures (9) and (10) show the effect of adding the four materials on the filtration and yield point. It was noted that the ninth and tenth models gave the lowest leaching volume and the highest yield point because they contained 0.5% of Nano silica and polyacrylamide. As these two materials are

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considered highly interactive and facilitate their compatibility with other ingredients and improve their water absorption and hydration capabilities.

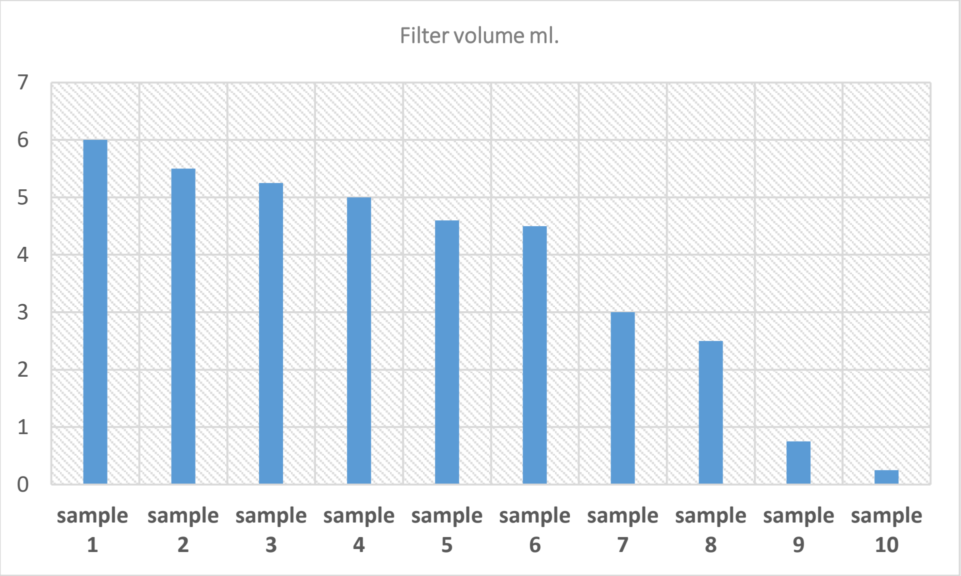

Fig. (9): Filter volume for the studied samples

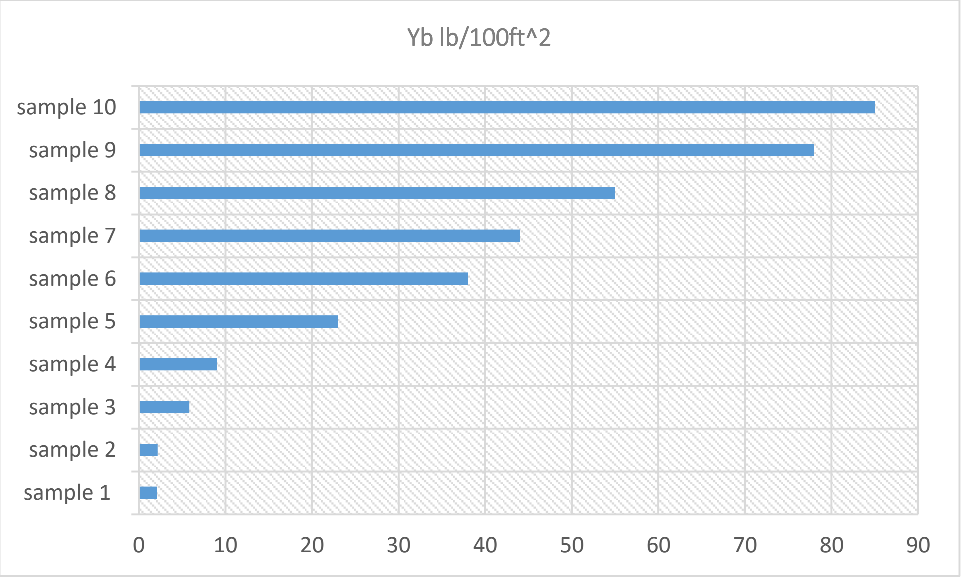

Fig. (10): Yield point for the studied samples

Figures (11) and (12) show laboratory results to study the effect of the studied materials on the thickness of the mud cake. The results showed that samples 9 and 10 have the lowest thickness of the mud cake, and this is due to the fact that their content of solids is very low. In addition, Nano silica and polyacrylamide have the ability to give a cohesive mud cake Low permeability and low thickness.

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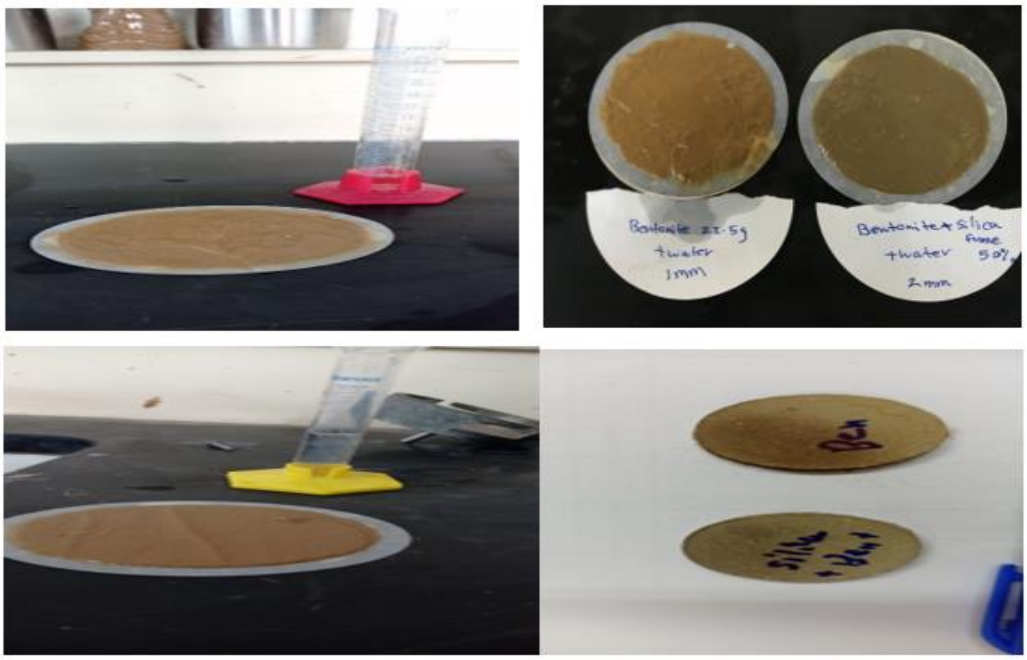

Fig. (11): Laboratory results filtration and mud cake.

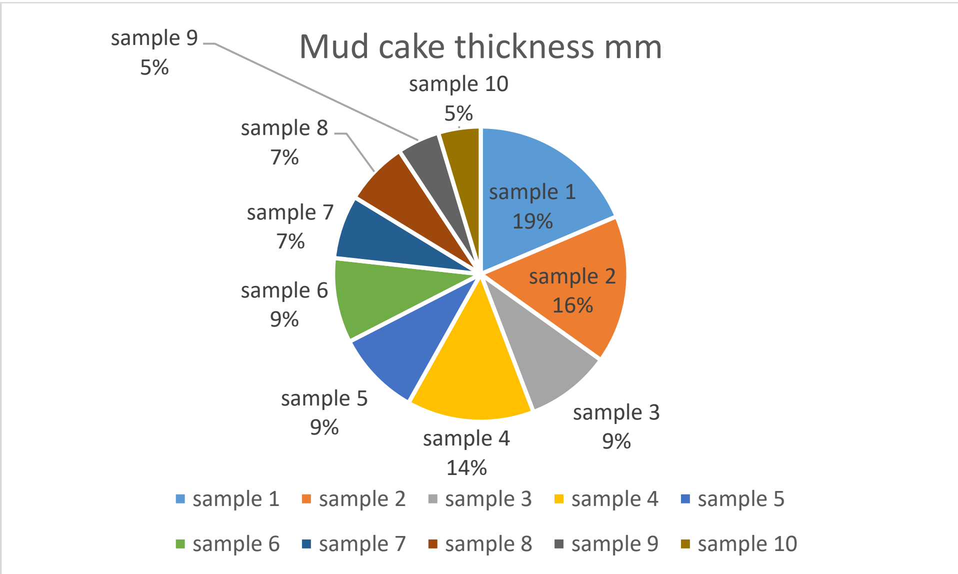

Fig. (12): Laboratory results (mud cake thickness).

Figure (13) shows the effect of increasing the percentage of solid matter on pressure loss and horse power. It was noted that increasing the percentage of solid matter is considered a burden on the hydraulic system, especially high percentages of 15% or more. It should be noted that increasing

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the percentage of solid matter means an increase in density and viscosity within practically unacceptable levels.

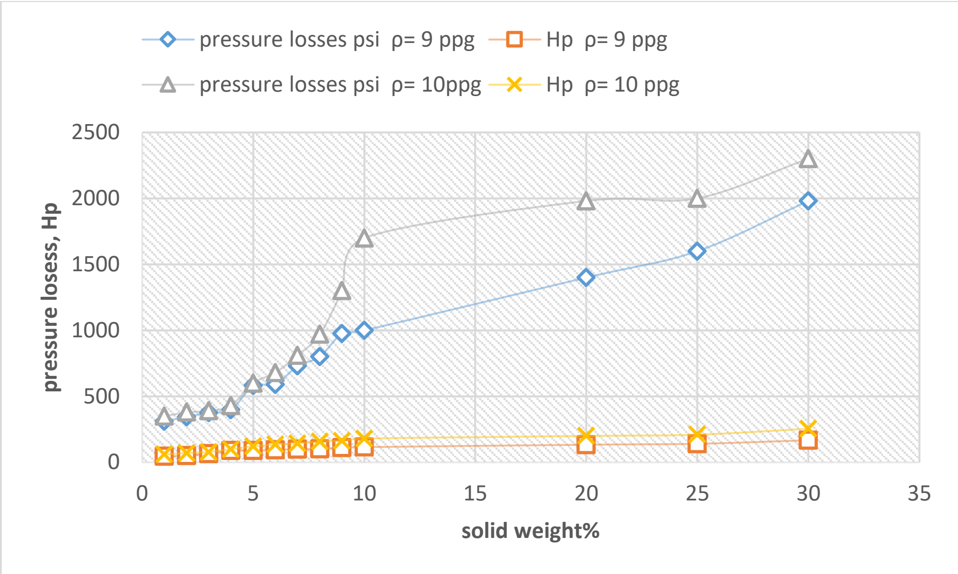

Fig. (13): Relation between solid by weight and pressure losses.

Tables (5) and (6) show the pressure drop calculation for a hydraulic system, where the pressure drop was calculated for ten drilling fluids that differ in their rheological properties. Field data were used in order to link the practical and theoretical parts of the study, as the studied fluids follow the power law depending on the relation between shear stress and shear rate as shown in Figure (14).

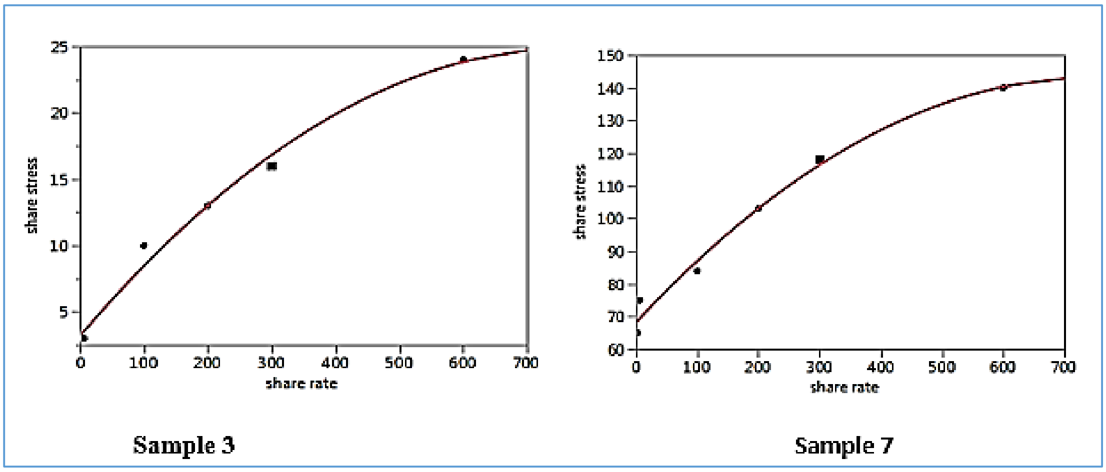

Fig. (14): Relationship between share rate and share stress for the studied samples

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Table (5): Calculation of Δ P_t, HP for a drilling fluid with a density of (9.5-10) Lb./gal

Fluid type	Sample 1	Sample2	Sample3	Sample4	Sample5
μp	1.5	5.04	13.2	22	45
N	0.502	0.765	0.76	0.773	0.729
K	0.157	0.061	0.167	0.25	0.725
ΔP_5 , Psi	30	30	30	30	30
Vc_1 , FPM	81.74	77	171	249	494
V_1 , FPM	343	343	343	343	373
ΔP_1 , Psi	58.3	74.3	90.2	99.78	113.2
Vc_2	90.6	90.6	207	302	589.6
V_2	634	634	634	634	634
ΔP_2 , Psi	28.3	36	43.69	48.33	55.76
ΔP_3 , Psi	162	162	126	162	162
Vc_3	110	110	173.7	253	494
V_3	305	305	350	305	305
ΔP_4	22.68	28.9	35.1	38.8	177
Vc_4	110	78	340	506	929.67
V_4	120	120	120	120	120
ΔP_5 , Psi	10.26	13.07	15.86	17.54	131.5
ΔP_T , Psi	311	344.3	376.8	396.45	381.5
HP	46	51	55.8	58.72	80.6

Table (6) Calculation table for drilling fluid of (8.5-9) lb./gal density with polymer additive

Fluid type	Sample6	Sample7	Sample8	Sample9	Sample10
μp	4	11	19	26	33
N	0.85	0.725	0.64	0.45	0.31
K	0.025	0.284	0.63	2.7	11.64
ΔP_5	30	30	30	30	30
Vc_1	41.2	213.8	294.8	4275	667.2
V_2	342	342	342	342	342
ΔP_2	76.9	102.7	105	111.4	243
Vc_3	51.69	254.6	340.7	467.5	705

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V_3	633.4	254.6	340.7	467.5	705
ΔP_3	37.36	50	51.06	52.1	94
ΔP_{Bit}	346.95	346.59	346.9	346.9	342.95
Vc_5	5503	350.3	546	1043	2092
V_5	304.6	304.6	304.6	304.6	304.6
ΔP_5	30	50.03	65.8	86.02	152
Vc_6	32.59	171.2	241	392	731.5
V_6	120	120	120	102	120
ΔP_6	13.5	34.044	53.8	103.5	243.8
ΔP_T	504	584.1	962.6	730	1066.3
HP	78.761	91.12	101.8	113.89	166.5

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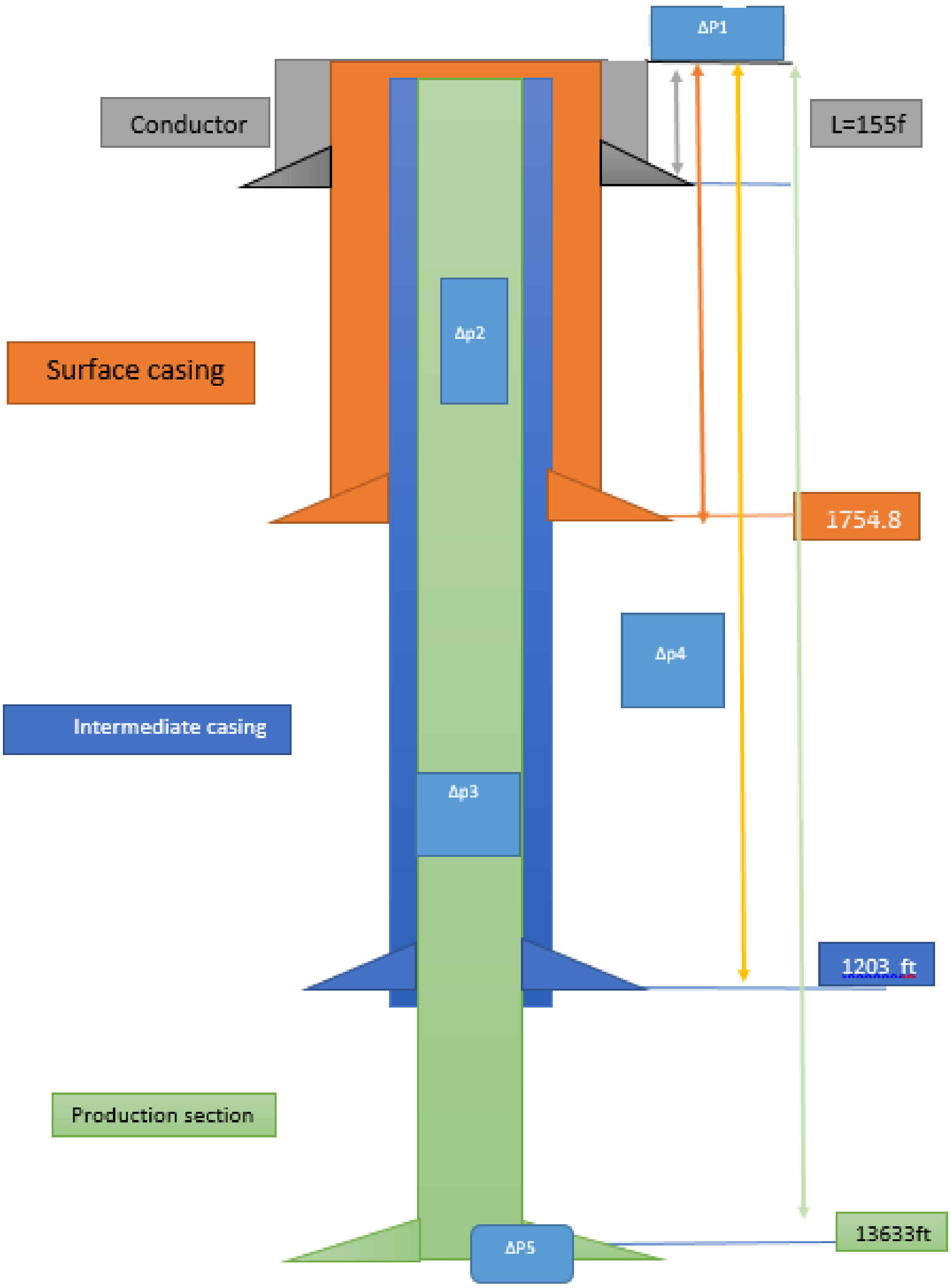

Fig. (15): Well schematics

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6. Conclusion:

One of the most important findings of the study is the possibility of using Iraqi bentonite to prepare drilling mud with low solids, and that the ideal ratio was for the third and fifth samples in this study, as shown by laboratory tests and hydraulic calculations. The high percentage of solids in the drilling fluid means an increase in viscosity, an increase in the thickness of the mud cake, an increase in the filtrate and an increase in density, which may cause a problem of loss and a decrease in the drilling speed. Silt insulator or mitigate using new clay. Low solid drilling fluid were effectively prepared by using high quality polymers for substituting a fragment of Iraqi bentonite in the mud system. The used polymers (polyacrylamide, sodium polyacrylate, micro silica and Nano silica) exhibited pseudo plastic performance, because of the excellent shear thinning features of polymer suspensions. Moreover, the, yield point, gel strength and viscosity of the mud increase with additions of polymers. In comparison, the fluids with bentonite only had lower values of viscosity, yield point, and gel strength and high solid content.

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