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# EFFECT OF DIFFERENT RAW MATERIALS ON RHEOLOGICAL PROPERTIES AND LOST CIRCULATION OF WATER-BASED MUD

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## Abstract

Without drilling fluid, it is impossible to drill oil and/or gas wells. Similarly, oil and gas wells cannot be drilled to total depths and reach their target without using engineered drilling fluids. The physical properties of a drilling fluid, rheological properties are monitored to assist in optimizing the drilling process. These physical properties contribute to several important aspects for successfully drilling a well, including Provide energy at the bit to maximize Rate of Penetration, remove cuttings from the well, Permit separation of drilled solids and gas at surface, Suspend cuttings and weight material during static periods.

Good planning and proper drilling practices are the keys to preventing lost circulation by minimizing excessive pressures on the formation. The best approach to control lost circulation is to make an assessment of the severity of a loss zone and match the remedial material and technique to it in terms of both the size of the material and its function. Lost-Circulation Materials

should match to the type and severity of the loss zone and has a light density. There must be a mixture of sufficient sizes to initiate and propagate an effective seal the formation and to bridge the opening to be plugged, in order to prevent further loss of drilling mud.

In this study, three types of Raw materials, namely (orange peels, banana peels, tea residue &hay) with different concentrations between 1 wt% to 5 wt% has been used to explore effect of Raw materials to the drilling fluid rheological properties are sensitive to the proposed materials,four rheological properties were investigated laboratory experimental way in this study which areplastic viscosity, yield point, gel strength, and mud filtration.

The laboratory analysis and results support the evidence that the presented Raw materials contain acceptable percentages of lignin which can control the fluid rheological properties. Thisstudy presents cost-effective local thinners for future well planning in Yemen oil fields.

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# Chapter One

## 1. Introduction:-

According to American Petroleum Institute (API), drilling fluid is defined as a circulating fluid used in rotary drilling to perform any or all of the various functions required in drilling operations To perform these functions, an efficient drilling fluid must exhibit numerous characteristics, suchas desired rheological properties (plastic viscosity, yield value and low-end rheology, gelstrengths), fluid loss prevention, stability under various temperatures and pressure operating conditions and also stability against contaminating fluids. The water-based drilling fluid should be designed to have a good carrying capacity (yield point) and an ideal filter cake (thin, impermeable, and fast formed). The ideal filter cake will reduce the fluid loss and decrease the formation damage. In addition, thin filter cake will help to avoid the common drilling problem such as differential sticking and this will reduce the total drilling cost.

## 2. Problem statement;

Uncertainties in planning the drilling fluid properties meant that operators faced more drilling challenges with inexplicable differences between the used and the required fluid properties

Chemical thinners such as tannins and lignosulphonate are natural and applicable but the major issue with theseadditives is that they are not locally available, and they are expensive

Lost circulation of drilling fluid that happens when the fluid flows into fractures of formation.

This study investigates four local materials as thinners to increase the efficiency of drilling fluid system. Thesematerials are(orange peels, banana peels, tea residue & hay).

This study presents cost-effective local thinners for future well planning in Yemen oil fields

## 3. Objectives of the study: -

1- Studding the traditional additives used to the drilling fluid to control the rheological properties.

2- Determining the effect of different Raw wastes such as orange peels, banana peels, leftover tea and hay on pH , rheological and filtration , filter cake of water-based drilling fluid.

3. Laboratory study the change in properties of drilling fluid using these Raw wastes.

4. Determine the size of concentration of material for curing lost circulation material andadditives for rheological properties.

# Chapter Two

## Literature Review

### 1. Introduction :-

Drilling fluid initially was prepared using basic clay and water, which has no impact on the environment However, with many problems encountered during drilling activities, complex chemicals or additives have been added to modify the mud to meet the best functions. The drilling fluid is classified according to its continuous phase such as water-based, oil-based, and gas-based drilling fluid The main function of the drilling fluid is to provide sufficient density to control the formation pressure, cool and lubricate the drill string and the bit, remove the drilled cutting from the formation, suspend the drilled cutting, decreasing the formation damage, seal the permeable formation by forming a filter cake on the face of t0he formation, and prevent corrosion The drilling fluids generally composed of polymers and solids. Polymers and clays are used to build the required viscosity and provide yield and gel strength properties (responsible for cutting suspension during the circulation and static processes). Among the typical viscosities being used in the industry are bentonite or attapulgite clay, carboxymethyl cellulose, and other polymers of which their main characteristics are waxy and gelling Clays and polymers provide the required rheological properties, which are very important during the drilling operation. Rheological properties include plastic viscosity, yield point, gel strength, and apparent viscosity. Plastic viscosity is the resistance to flow, and it results from the friction between the fluid layers and the friction between the solid particles with the drilling fluid. The yield point is defined as the ability of the drilling fluid to carry and keep the drilled cutting in suspension while circulating the drilling fluid. Gel strength has the same definition of the yield point by in the case of static conditions

## 2. Lost Circulation Definition and Classification

### 2.1. Definition

Lost circulation can be defined as the lost of drilling fluid or cement slurries into the formation. The problem of lost circulation encountered during drilling is caused by the differential pressureof the hydrostatic column which is generally greater than the formation pressure and it moves especially through the openings in the rock in low pressure or depleted zone.

### 2.2. Classification of losses

Losses can be classified as naturally occurring losses which is resulting from the formation b eing drilled and mechanically induced losses which is caused by the over pressuring and fracturing the formation during drilling operation.

There are four types of formations which are responsible for lost circulation such as: Natural

- formation fracture
- Vugular or cavernous
- formationHighly permeable

  formation
- Unconsolidated formation

The most common causes of mechanically induced losses are:

- High hydrostatic pressure resulting from an excessive mud weight.
- High hydrostatic pressure resulting from an excessive annular cutting load.
- High hydrostatic pressure resulting from an excessive Equivalent Circulation Density.
- High downhole pressure resulting from a restricted annulus.

## 3. Lost Circulation Materials

According to Offshore Mineral Management Glossary, lost circulation material (LCM) is defined as a substance added to cement slurries or drilling mud to prevent the loss of cement or mud to the formation. The substance may contain a blend of granular, fibrous and flake material with particle size distribution believed to be large enough to form bridge of material in the fracture orcavern. It is important that the bridge be within the formation and not on the surface of the wellbore where it can be dislodged by the drill pipe.

Industry has developed the following three basic types of agents depending on the operational phase of the well to combat lost circulation.

1. Bridging agents
2. Gelling agents
3. Cementing agents

Bridging agents are found effective to handle lost circulation problems and are classified in respect to their morphology as fibrous, flake, granular and blended.

## 4. Drilling Fluid

Drilling fluids are typically classified according to their base material. The drilling mud may be either a water-based mud having solid particles suspended therein or an oil-based mud with wateror brine emulsified in the oil to form a discontinuous phase and solid particles suspended in the oil continuous phase. Water based drilling fluid which includes an aqueous fluid, at least one of a weighting agent and a gelling agent, and a lubricant, which includes at least one ester derivative.Water-based drilling fluids may be suitable for drilling in certain types of formations; however, for proper drilling in other formations, it is desirable to use an oil-based drilling fluid. During thedrilling operations, the drilling fluid is injected into the well through the drill pipe and recirculated to the surface in the annular area formed by the wellbore wall and the drill string. Once back at the surface, the drilling fluid is physically and chemically treated and conditioned before it is pumped back into the well.

## 4.1. Drilling Fluid Properties

### 4.1.1. Mud Density

Mud density is used to control subsurface pressures and stabilize wellbore and it is commonly measured with a mud balance capable of +0.1 lb/gal accuracy. A mud balance calibrated with fresh water at 700 + 50 should give reading of 8.3 lb/gal. When we drill the wellbore, we replace a cylinder of rock with a cylinder of mud. The first critical step towards designing a drilling fluid is to establish the mud weight required to provide the correct level of borehole pressure support.

2.1) Density, $\rho$ = mass / volume (unit in ppg)

### 4.1.2. Rheology

Rheology is the science of deformation and flow of matter. By making certain measurements on a fluid it is possible to determine how that fluid will flow under a variety of conditions, including temperature, pressure and shear rate.

Rheological properties measured with a rotational viscometer are commonly used to indicate solid buildup flocculation or deflocculation of solids, lifting and suspension capabilities, and to calculate hydraulics of drilling fluid. A rotational viscometer is used to measure shear rate or shear stress of drilling fluid from which the Bingham Plastic parameters,

**VISCOSITY**

Of the rheological terms, viscosity is the most familiar. Viscosity in its broadest sense can bedescribed as a substance's resistance to flow. In the oilfield, the following terms are used to describe drilling fluid viscosity and rheological properties:

1. Funnel viscosity (sec/qt or sec/L).
2. Apparent viscosity (cP or mPa•sec).
3. Effective viscosity (cP or mPa•sec).
4. Plastic viscosity (cP or mPa•sec).
5. Yield point (lb/100 ft2 or Pa).
6. Low-shear viscosity and Low-Shear-Rate Viscosity (LSRV) (cP or mPa•sec).
7. Gel strengths (lb/100 ft2 or Pa).

These are among the key values for treating and maintaining drilling fluids.

## 4.2. Additive in Drilling Fluid

Additive in drilling fluid consist of weighting agent, deflocculation or dispersing agent, filtration control agent and viscosifying agent. Table 1 summarizes the types of additive used base on its function on drilling fluid.

### 4.2.1. Function of drilling additive

1. Enhancing Lubrication Additives like friction modifiers, anti-wear agents and extreme pressure additives create a layer of protection between the moving metal surfaces and reduceheat and wear.
2. Maintaining Temperature Coolants and anti-freeze additives regulate the temperature of fluids, preventing them from overheating or freezing in extreme conditions.
3. Improving Stability Stabilizers and dispersants prevent unwanted reactions between fluids,slowing down degradation and prolonging shelf life.

**Table2.1: Types of additives base on its function in drilling fluid**

| Weighting agents | Deflocculation agent | LOST-CIRCULATION MATERIALS | Viscosifying agent |
|---|---|---|---|
| API barite barium<br>For increasing<br>densityto 20 lb/gal.<br><br>Hematite iron oxide<br>For increasing<br>density to 25 lb/gal.<br><br>calcium carbonate<br>Acidsoluble<br>weighting and<br>bridging agent for<br>increasing density<br>to12lb/gal . | Lignite<br>Thinner, emulsifier<br>andfluid-loss control.<br><br>Chrome lignite<br>High-<br>temperature<br>thinner,<br>emulsifier,<br>and fluid-loss control.<br><br>Modified chrome<br>tannin Thinner and<br>protective colloid. | Micronized<br>cellulose<br>fiber<br>Bridging and<br>sealingpermeable<br>formations.<br><br>Mica<br>Flake LCM for<br>seepagelosses and<br>prevention.<br><br>Sized graphite<br>Lost circulation<br>andseepage. | Wyoming<br>bentonite<br>Viscosity<br>and filtration control.<br><br>Attapulgite<br>Viscosity in saltwater<br>muds.<br><br>API sepiolite<br>Viscosity for<br>freshwater,<br>saltwaterand<br>high-temperature<br>geothermal muds. |

## 4.3. <u>Previous studies</u>

There are several studies that have advanced the use of fruit peels in oil drilling fluids. Fruit peels contain organic and anti-corrosive substances that can be useful in drilling operations andimprove the performance of drilling fluids. One of the potential benefits of using fruit peels in drilling fluids is reduced corrosion. The scales contain anti-corrosion substances such as vitamins and minerals that can protect the drilling equipment from corrosion and extend its life.Moreover, fruit peels can increase the viscosity of the fluids in the pits. This may help increase the ability of the fluid to hold the hard bits and reduce fracturing of the natural stone during drilling operations. Some research also indicates that the use of fruit peels can improve the ability of drilling fluids to handle high temperatures. The scales contain materials that retain heat and protect the liquid from the harmful effects of high temperatures.

However, it must be noted that there are several challenges that need to be overcome to effectively sample fruit peels during drilling operations. The process of extracting the active substances from the peels and improving the availability of these substances in the liquid must be optimized. Researchers should also evaluate the impact of using fruit peels on the environment and economics to achieve more benefits.

Although there are some studies that point to the potential benefits of using foie gras

There are several fruits whose peels can be used in oil drilling fluids, including:

1. Coconut Husk: Coconut Husk contains compounds that help improve the viscosity of thedrilling fluid and protect equipment from corrosion.
2. Avocado peels: Avocado peels contain anti-corrosion compounds and the ability to withstandhigh temperatures, and thus can be used in drilling fluids.

It should be noted that the use of fruit peels in oil drilling fluids is still in the research and development stage, and it requires further studies and tests to improve its efficiency and effectiveness in practical applications.

# Chapter Three

# Materials and Methods

## 1. Introduction:-

In this chapter, a brief description regarding the tested materials and laboratory devices is given.The used materials are organic wastes represented by orange peels, banana peels, leftover tea, and hay whereas the used devices are mainly pH, filtration and viscometer instruments.

## 2. Materials

### 2.1. Banana peels

Banana are produced in large quantities in tropical and subtropical areas. After harvesting fruit, the peels are traditionally wasted. This waste material creates great environmental problems whenleft on the plantation floor. Therefore, economic utilization of this plant waste fiber will be beneficial. The peels of banana contains of fiber which is potentially used as a lost circulation material in drilling fluid.

Table3.1 shows the percentage of various chemical components present in different types of plant waste fibers. Clearly, banana (peels) contains of high composition of cellulose fibers which can be used as a lost circulation material in drilling fluid.

**Table 3.1: Chemical composition of different lignocellulosic fibers**

| **Composition(% )** | **Oil palm frond** | **Cocon ut** | **Pineapple leaf** | **Banana stem** | **Softwoo d** |
|---|---|---|---|---|---|
| Extractive | 6.4 | 6.4 | 5.5 | 10.6 | 0.2-8.5 |
| Holocellulose | 56.3 | 56.3 | 80.5 | 65.2 | 60-80 |
| -cellulose | 44.2 | 44.2 | 73.4 | 63.9 | 30-60 |
| Lignin | 32.8 | 32.8 | 10.5 | 18.6 | 2-37 |
| As h | 2.2 | 2.2 | 2.0 | 1.5 | <1 |

Lignin is a chemical compound (complex, highly cross-linked aromatic polymer) that is most commonly derived from wood and is an integral part of the cell walls of plants, especially in tracheids, xylem fibers and sclereids. Lignin fills the spaces in the cell wall between cellulose, hemicellulose and pectin components. It is covalently linked to hemicellulose. It also forms covalent bonds to polysaccharides and thereby crosslinks different plant polysaccharides. Lignin plays a crucial part in conducting water. The polysaccharide components of plant cell walls are highly hydrophilic and thus permeable to water, whereas lignin is more hydrophobic. The cross linking of polysaccharides by lignin is an obstacle for water absorption to the cell wall. Thus, lignin makes it possible for the plant's vascular tissue to conduct water efficiently.

On the other hand, cellulose is a long chain of glucose molecules, linked to one another primarily with glycosidic bonds. The simplicity of the cellulosic structure, using repeated identical bonds, means that only a small number of enzymes are required to degrade this material.

Ash is one of the components in the proximate analysis of biological materials, consisting mainly of salty, non-organic constituents. It includes metal salts which are important for processes requiring ions such as Na+ (Sodium), K+ (Potassium), Ca+ (Calcium). It also includes trace minerals which are required for unique molecules, such as chlorophyll and hemoglobin.

**Fig3.1:Banana peels after grinding**

### 2.1.1. Properties of Micronized Cellulose Fibers

Cellulose fibers have demonstrated the unique characteristic of quickly forming a seal at the facepreventing entrance of damaging fluids or solids into producing formations. Compared to the more rigid and brittle inorganic solids such as sized calcium carbonate, sized salts or fibrous calcium silicates, certain types of micronized cellulose fibers are flexible, highly compressible, slightly swellable and partially extrudable. As a result, properly selected cellulose fibers have the ability to form quick, surface seals and minimize the penetration of solids or liquids into the formation.

Micronized cellulose fibers can effectively forms seals at much lower concentrations than the more commonly used acid or water soluble inorganic seepage loss additives. In spite of this, micronized cellulose fibers have been restricted to use in drilling operation. They have had limited use in payzone fluids because of their very low acid solubility.

It has been demonstrated that micronized cellulose fibers are highly soluble in concentrated alkaline solutions. Alkaline removal solutions are just as effective in removing these cellulose fibers as acids are in removing calcium carbonate or some types of calcium silicate fibers.

### 2.1.2. Advantages of Micronized Cellulose Fibers

There are many types of cellulose material and not all are fibrous. Fibrous cellulose has very distinct advantages over granular or flake materials, such as orientation, matting, compressibility, deformability and an almost infinite particle size distribution. One of the most important advantages of micronized cellulose fibers is orientation. As dynamic of flow, fibers gravitate toward the area of slowest flow. They tend to drag along the borehole or perforation tunnel, orienting end first as they enter the formation. Then, corkscrew or pig tail as they fill the pore throat, quickly forming protective seal. They will also enter the formation and lay flat against the borehole or perforation tunnel gripping the formation while creating a matting effect increasing wall cake strength and integrity.

Another distinct advantage of fibers over granular and flaked cellulose is their infinitely variableparticle size distribution. Particle size analysis and distribution have become an integral part of drilling fluid design. Particles necessary for a quick seal and thin, tough wall cake must be compressible and deformable. Because fibers will lay in fractures, orient and fill very small pore throats, pig tail or corkscrew to fill larger pore spaces, their particle size distribution is almost infinity variable. This accounts for the quick sealing characteristic of cellulose fibers in a wide range of permeabilities and porosities.

Field experience has shown that for a drilling fluid to have adequate plugging characteristic, the spurt loss must be below 5 $cm^3$ and made up entirely filtrate. This allows the formation to be plugged quickly, creating a thin impermeable wall cake. By quickly forming a near surface seal,the cellulose fibers are easily accessible for removal. A highly alkaline pill can be spotted at the formation face and allowed to solubilize the fibers without the need for injection of large amounts of fluid into the formation, reducing the possibility of damage from potential precipitates.

### 2.1.3. Disadvantages of Micronized Cellulose Fibers

Although the cellulosic fibers themselves provided a positive seal in the mud sample in the laboratory, the seal appeared to be short lived and unstable when field tested. Any foreign material introduced into any formation will cause some degree of formation damage, especially if the foreign material enters the formation matrix. The specially formulated LCM blend is no exception. On the basis of the laboratory test results, formation damage caused by the specially formulated LCM blend can be minimized by perforating beyond the damage zone or HCI or NAClO treatment.

## 2.2. Orange peels

Orange as the main citrus fruit is one of top-five fruit commodities that dominate the global fruitmarket. According to Food and Agriculture Organization, global orange production reached 68 million tons representing 8.5% of the total fruit production [12]. The largest orange producers are Brazil, United States of America, China, India, and Mexico in 2012 [12]. Approximately, 40– 60% of oranges are processed for juice production, of which 50–60% ends up as waste including seed, peel, and segment membrane [13, 14]. The generation of these solid wastes is estimated tobe in the range of 15 to 25 million tons per year [14]. Among these wastes, citrus peel is the major constituent accounting for approximately 44% of the weight fruit mass [15].Citrus waste for different applications such as production of pectin, flavonoid, fiber, and animal feed production has been proposed by several researchers [16–19]. However, a large amount of this waste is still dumped every year [20], which causes both economic and environmental problems such as high transportation cost, lack of dumping site, and accumulation of high organic content material [21]. Therefore, more effective and sustainable alternatives are using orange peel wastes such as organic drilling mud property enhancer since they give benefitsin terms of both saving money and environmental aspects. Orange peel waste contains both soluble and insoluble carbohydrates that can be digested to biogas.

Organic colloids, usually called polymers, are high molecular weight, water dispersible organic polymers that control either the rheological or fluid loss properties of the fluid. They are essential for maintaining those fluid properties in brine-based fluids.

**Fig3.2: Orange peels after grinding**

## 2.3. <u>Tea Residue</u>

The problems of reducing fluid loss from drilling wells have been recognized and addressed for decades. The generic causes of fluid loss from boreholes to the surrounding earth formations are well-known. They include: natural fractures in the rocks drilled, induced fractures when pressure in the drilling fluid exceeds fracturing stress of the earth, cavernous formations, and highly permeable formations. Unfortunately, the cause of fluid loss in drilling a particular well is not always known. Therefore, a variety of responses

are often employed in attempts to control loss of fluid from a well. A variety of naturally occurring products have been used as lost circulation materials in the past.

Another material derived from plants and available in industry is tea residue. It is a material whichhas the ability to reduce fluid loss rate through a mat or cake of fine solid materials.

**Fig3.3: Tea residue after grinding**

## 2.4. <u>Hay</u>

Hay is grass, legumes, or other herbaceous plants that have been cut and dried to be stored for use as animal fodder

Commonly used plants for hay include mixtures of grasses such as ryegrass and other species, depending on region. Hay is very sensitive to weather conditions Thus the biggest challenge and risk in producing hay crops is the weather, especially the weather of the particular few weeks when the plants are at the best age/maturity for hay. the hay content about 39% of starch, and thedigested protein ranges between 5-16%.

**Fig3.4:hay after grinding**

3. **Procedure of sample test**

- Measure 350ml of water.
- Modify PH to 9.5 by Caustic Soda (NaOH)
- Add 15 g of bentonite to the water in the mixing device bowl and allow time to mixfor 15 minutes.
- Check the pH and it should be 9.5 (if the PH value is less than 9.5, we add causticsoda dissolved in the water until the value reaches 9.5).

Add the substance whose effect you want to know (orange peels, tea residues, banana peels, etc.) and let it mix a little

- pH check and measurement
- Checking other properties: PV YP, GS, SS&Ø, and we measure it with a viscometer
- Measuring mud cake thickness for each sample by means of a filtering device and measuringthe volume of filtered liquid through (2.5m,5m,10m,15m,20m,25m&30m)

## 4. Devices used in the research

**1. Mixers**
**2. Fann viscometer**
**3. PH meter**
**4. Filtration**

### 4.1. Mixers

Shale Tech Solutions SRL distribution exclusive de FANN para la Argentina Most drilling fluid formulations contain a base liquid and additives which must be dissolved or mechanically dispersed into the liquid to form a homogenous fluid. The resulting fluid may contain one or more of the following: water-dispersible (soluble) polymers or resins, clays or other insoluble but dispersible fine solids, and soluble salts.

The fluids are mixed or sheared for times appropriate to achieve a homogenous mixture and are then set aside to "*age*." Drilling fluid aging is the process in which a drilling fluid sample, previously subjected to a period of shear, is allowed to more fully develop its rheological and filtration properties. Aging is done under conditions which vary from static to dynamic and from ambient to highly elevated temperatures.

•

Hamilton Beach Mixers, Single and Three-Speed Models are recommended for use in general purpose mixing of drilling fluids in preparation for laboratory tests of mud materials. The ThreeSpindle Model has independent speed controls for each spindle.
These mixers can also be used to mix cement for field or laboratory testing.


**Fig3.5: mixer Hamilton beach**

## 4.2. Fann viscometer

Also known as direct-indicating viscometer or V-G meter, an instrument used to measure viscosity and gel strength of drilling mud. The direct-indicating viscometer is a rotational cylinder and bob instrument. Two speeds of rotation, 300 and 600 rpm, are available in all instruments, but some are 6- or variable-speed. It is called "direct-indicating" because at a given speed, the dial reading is a true centipoise viscosity. For example, at 300 rpm, the dial reading (511 $sec^{-1}$) isa true viscosity.

Bingham plastic rheological parameters are easily calculated from direct-indicating viscometer readings: PV (in units of cP) = 600 dial - 300 dial and YP (in units of lbm/100 $ft^2$) = 300 dial - PV. Gel strength is also directly read as dial readings in oilfield units of lbm/100 $ft^2$.

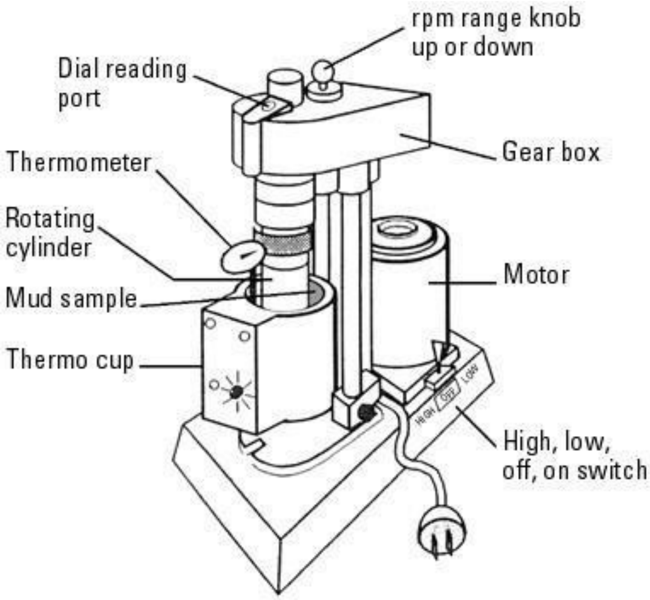



**Fig3.6: viscometer OFITE model 900**

### 4.2.1. Operating methods of viscometer

- Connect the device to an electrical source.
- Place the form in the device housing.we press clear / stop
- We press MUD
- Take the values . (Ø300, Ø600).
- We wait 10 minutes.
- We take the values (PV, YP, $GS10_{sec}$, $GS10_{min}$).
- click on stop.
- We take the values (SS600, SS300, SS100, SS10, SS6, SS3).
- We find the value of µa by dividing Ø600 by 2.
- Turn off the appliance, empty the bowl and clean it.

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## 4.3. pH meter


Fig3.7: PH meter by hanna

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH. The pH meter measures the difference in electrical potential between a pHelectrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter". The difference in electrical potential relates to the acidity or pH of the solution. The pH meter is used in many applications ranging from laboratory experimentation to quality control.

## 4.4. Filtration

### 4.4.1. Theory

The loss of liquid from a mud due to filtration is controlled by the filter cake formed of the solid constituents in the drilling fluid. The test in the laboratory consists of measuring the volume of liquid forced through the mud cake into the formation drilled in a 30 minute period under given pressure and temperature using a standard size cell. It has been found in early work that the volumeof fluid lost is roughly proportional to the square root of the time for filtration, i.e. “**$V \propto \sqrt{t}$**” The two commonly determined filtration rates are the low-pressure, low-temperature and the high- pressure high-temperature.

### 4.4.2. Test Equipment

The low-pressure test is made using standard cell under the API condition of 100 + 5 psi for 30 minutes at room temperature. Another special cell, will be used to measure filtration rate at elevated temperatures and pressure. Filter press used for filtration tests consists of four independent filter cells mounted on a common frame.

Each cell has its own valve such that any or all the cells could be operational at the same time. Toggle valve on the top of each cell could be operated independently for the supply of air for each individual cell. Special high pressure and high temperature filtration tests are run in the laboratory simulating formation temperature and formation back- pressure.

### 4.4.3. Operating methods of Filtration

- Connect the tools as shown in the fig3.8

- We open the pump valve gradually after we set the pressure to 6.8bar (100psi) in the field and we notice water drops that are support losses that we get rid of or eliminate from Later measure.

  We open the main valve and set the timer to 2.5m and take the reading from the cylinder andthen take the rest of the readings according to the timings mentioned previously
- After completing the volume measurements, we get rid of the form, take out the filter paper, note the formation of a clay cake on it and measure its thickness with a graduated ruler.
- We wash all tools.

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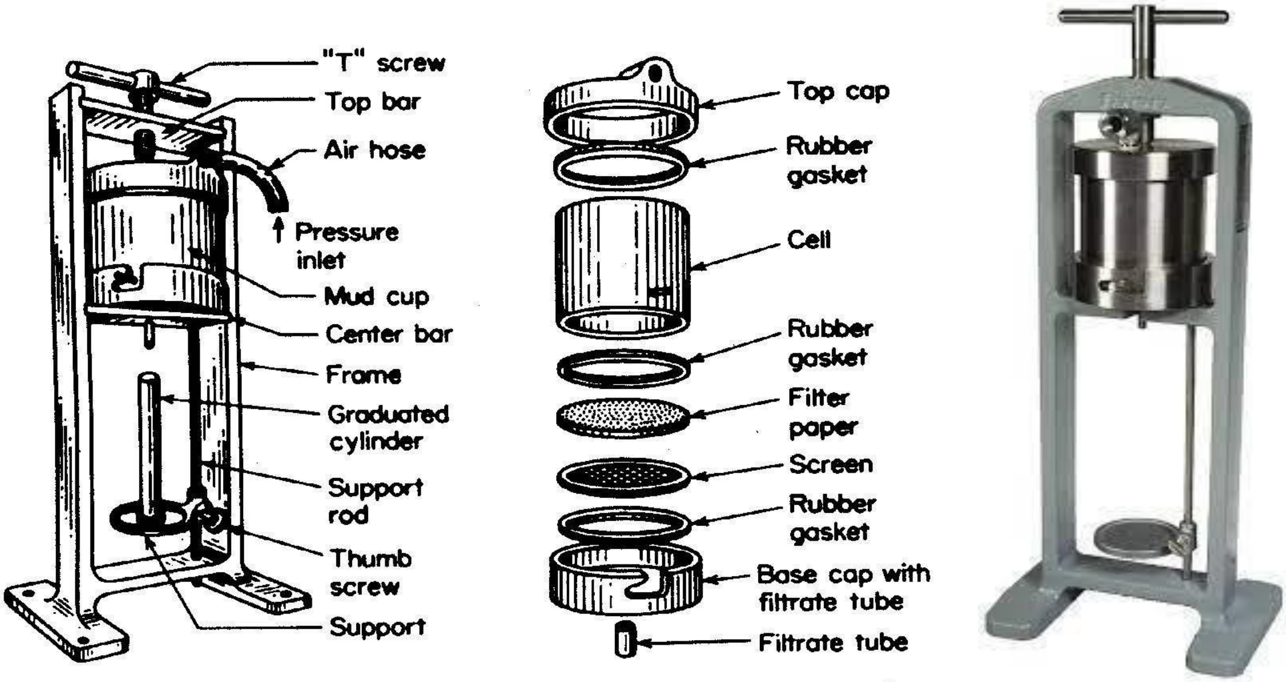



**Fig 3.8: Filter press device**

# Chapter Four

## Results and discussion

### 4.1.Properties of Drilling Fluid

Sample 1 is the base case for this experiment while the other drilling mud samples were prepared in order to measure the change in properties such as plastic viscosity, apparent viscosity, yield point, gel strength and filtration loss as compared to the base case (sample 1) as summarized in Table 4.1. and particle size of all additive 0.03mm. in room temperature 68°F

**Table 4.1: Laboratory prepared samples.**

| 1 | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| **Water, ml** | 350 | 350 | 350 | 350 |
| **Bentonite, gm** | 15 | 15 | 15 | 15 |
| **Orange peels, gm** | 1 | 2 | 3 | 5 |
| **Banana peels, gm** | 0 | 0 | 0 | 0 |
| **Tea Residue , gm** | 0 | 0 | 0 | 0 |
| **hay, gm** | 0 | 0 | 0 | 0 |
| **(NaOH),gm** | 0.03 | 0.03 | 0.03 | 0.03 |

•

| 2 | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| Water, ml | 350 | 350 | 350 | 350 |
| Bentonite, gm | 15 | 15 | 15 | 15 |
| Orange peels, gm | 0 | 0 | 0 | 0 |
| Banana peels, gm | 1 | 2 | 3 | 5 |
| Tea Residue , gm | 0 | 0 | 0 | 0 |
| hay, gm | 0 | 0 | 0 | 0 |
| (NaOH),gm | 0.03 | 0.03 | 0.03 | 0.03 |

| 3 | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| Water, ml | 350 | 350 | 350 | 350 |
| Bentonite, gm | 15 | 15 | 15 | 15 |
| Orange peels, gm | 0 | 0 | 0 | 0 |
| Banana peels, gm | 0 | 0 | 0 | 0 |
| Tea Residue , gm | 1 | 2 | 3 | 5 |
| hay, gm | 0 | 0 | 0 | 0 |
| (NaOH),gm | 0.03 | 0.03 | 0.03 | 0.03 |

| 4 | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| **Water, ml** | 350 | 350 | 350 | 350 |
| **Bentonite, gm** | 15 | 15 | 15 | 15 |
| **Orange peels, gm** | 0 | 0 | 0 | 0 |
| **Banana peels, gm** | 0 | 0 | 0 | 0 |
| **Tea Residue , gm** | 0 | 0 | 0 | 0 |
| **hay, gm** | 1 | 2 | 3 | 5 |
| **(NaOH),gm** | 0.03 | 0.03 | 0.03 | 0.03 |

### 4.1.1.Basic drilling fluid )Bentonite in Drilling Fluids WBM)

Bentonite is montmorillonite clay which is used with the drilling fluids to provide the required rheology. Bentonite is mainly used with water-based mud (WBM) to provide significant functions such as increasing the viscosity and filtration control. Bentonite interacts chemically with the water and swells as it absorbs the water as a result. Bentonite as clays are naturally absorbent, and when the bentonite is exposed to water, bentonite attracts with the positively charged surfaces inwater to its negative face by electrostatic attraction forces. This phenomenon enables thebentonite to absorb seven to 10 times its weight and swell up to 18 times its original volume. Bentonite reacts chemically with several organic materials and forms compounds that are mainlyused as gelling agents. The mud gel strength is important for carrying the drilled cuttings in caseno mud circulated. Sodium bentonite is used in the drilling mud, is highly dispersive, and has a high swelling capability. Calcium bentonite is another type of bentonite, but it is not appropriate to be used as drilling fluid additive since it has the small swelling capability and it affects the mud rheology badly. The raw bentonite is extracted and processed through many purification operations to be properly used with the drilling fluids. Mechanical and chemical processes are conducted for the raw bentonite such as sieving or adding chemicals to separate the pure bentonite from the impurities. The good quality of bentonite affects the mud rheological properties as it provides the essential viscosity and filtration loss.

**Fig4.1: bentonite**

**Table 4.2: Properties (pv, yp, $\mu_a$, $Gs_{10sec}$&$Gs_{10min}$) of each additive**

| Drilling Parameter | Orange peels | | | | Banana peels | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample4 5gm |
| Pv (cp) | 4.6 | 7.6 | 10 | 8.5 | 3.7 | 3.4 | 3.1 | 4.3 |
| Yp (lb/100 ft²) | 5.7 | 4.1 | 5 | 7.2 | 9.1 | 5.5 | 7.2 | 6.6 |
| $\mu_a$ (cp) | 7.25 | 9.55 | 12.35 | 11.6 | 8.05 | 6.05 | 6.5 | 7.45 |
| $Gs_{10s}$ (Pa) | 2.7 | 3 | 5.6 | 3.2 | 7.2 | 5.1 | 5.8 | 5.9 |
| $Gs_{10m}$ (Pa) | 7.5 | 9.5 | 9.8 | 6.6 | 11.5 | 7 | 7.6 | 9.6 |
| PH before add | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| PH after add | 8 | 8.3 | 9 | 7.7 | 9.1 | 8.9 | 8.8 | 8.5 |
| **Drilling Parameter** | **Tea Residue** | | | | **Hay** | | | |
| | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample4 5gm |
| Pv (cp) | 4 | 3.1 | 3.8 | 4.4 | 2.9 | 3.1 | 4 | 4.5 |
| Yp (lb/100 ft²) | 15.5 | 4.1 | 7.4 | 6.3 | 7.4 | 8.2 | 7.1 | 6.6 |
| μa (cp) | 11.3 | 5 | 7.25 | 7.35 | 6.45 | 6.85 | 7.35 | 10.55 |
| $Gs_{10s}$ (Pa) | 13.8 | 2.8 | 5.6 | 4.9 | 5.9 | 6.1 | 6.8 | 11.4 |
| $Gs_{10m}$ (Pa) | 18.4 | 4.6 | 9.2 | 8 | 8.2 | 7.6 | 8.4 | 13.7 |
| PH before add | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| PH after add | 9 | 8.3 | 8.2 | 7.5 | 9.1 | 8.6 | 8.4 | 8.5 |

## Table 4.3: Property (Share Rate) of each additive

| | Orange peels Ø ($Sec^{-1}$) | | | | Banana peels Ø ($Sec^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| RPM | Sample1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm |
| 600 | 14.5 | 19.1 | 24.7 | 23.2 | 16.1 | 12.1 | 13 | 14.9 |
| 300 | 9.9 | 11.5 | 14.6 | 15.2 | 12.3 | 8.7 | 9.9 | 10.6 |
| | Tea Residue Ø ($Sec^{-1}$) | | | | Hay Ø ($Sec^{-1}$) | | | |
| RPM | Sample1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm | Sample 1 1gm | Sample 2 2gm | Sample 3 3gm | Sample 4 5gm |
| 600 | 22.6 | 10 | 14.5 | 14.7 | 12.9 | 13.7 | 14.7 | 21.1 |
| 300 | 18.6 | 7 | 10.8 | 10.4 | 9.9 | 10.8 | 10.7 | 16.5 |

## Table 4.4: Property (Share Stress) of each additive

| | Orange peels SS(Pa) | | | | Banana peels SS(Pa) | | | |
|---|---|---|---|---|---|---|---|---|
| RPM | Sample1 1gm | Sample2 2gm | Sample3 3gm | Sample4 5gm | Sample1 1gm | Sample2 2gm | Sample3 3gm | Sample4 5gm |
| 600 | 16.6 | 21.5 | 24.5 | 27.1 | 18.3 | 13.2 | 14.3 | 16.3 |
| 300 | 10.8 | 12.3 | 13.9 | 15.5 | 13.3 | 9.3 | 11 | 11.3 |
| 100 | 5.6 | 6.5 | 7.5 | 7.7 | 8.7 | 5.5 | 6.8 | 6.7 |
| 10 | 2.7 | 2.7 | 3.7 | 2.9 | 5.7 | 3.7 | 4.9 | 4 |
| 6 | 2.7 | 2.6 | 3.7 | 2.8 | 5.9 | 3.7 | 4.8 | 4.1 |
| 3 | 2.7 | 2.5 | 3.6 | 2.7 | 6 | 3.6 | 4.8 | 4.1 |
| | Tea Residue SS(Pa) | | | | Hay SS(Pa) | | | |
| RPM | Sample1 1gm | Sample2 2gm | Sample3 3gm | Sample4 5gm | Sample1 1gm | Sample2 2gm | Sample3 3gm | Sample4 5gm |
| 600 | 24.7 | 11.4 | 16.5 | 16.4 | 14.5 | 15.7 | 15.7 | 22.3 |
| 300 | 20.6 | 7.7 | 12.4 | 11.5 | 10.8 | 11.5 | 11.5 | 17.2 |
| 100 | 16.6 | 4.2 | 7.9 | 7.1 | 7 | 7.1 | 7.8 | 12.5 |
| 10 | 12.6 | 2.4 | 5 | 4.4 | 4.7 | 5.2 | 5.7 | 9.7 |
| 6 | 12.7 | 2.3 | 4.9 | 4.5 | 4.7 | 5.3 | 5.7 | 9.8 |
| 3 | 12.8 | 2.3 | 4.9 | 4.5 | 4.9 | 5.3 | 5.7 | 9.7 |

**Table 4.5: Property (Filtration) of each additive**

| Parameter | Base Drilling Mud | | | | | | |
|---|---|---|---|---|---|---|---|
| Time(Min) | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 |
| Volume (CC) | 5 | 7 | 8 | 12 | 12.8 | 14.4 | 15.7 |
| Mud cake thickness(mm) | 1.5 | | | | | | |
| **Parameter** | **3gm Orange Peels** | | | | | | |
| Time(Min) | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 |
| Volume (CC) | 6.2 | 8.8 | 12.9 | 15.3 | 17.6 | 20.1 | 21.8 |
| Mud cake thickness(mm) | 3 | | | | | | |
| **Parameter** | **2gm Tea Residue** | | | | | | |
| Time(Min) | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 |
| Volume (CC) | 2.9 | 4.5 | 7 | 8.7 | 11 | 12.5 | 13.9 |
| Mud cake thickness(mm) | 1.75 | | | | | | |
| **Parameter** | **2gm Banana peels** | | | | | | |
| Time(Min) | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 |
| Volume (CC) | 6.9 | 9.7 | 13.8 | 17.1 | 19.7 | 22.4 | 24.7 |
| Mud cake thickness(mm) | 3 | | | | | | |
| **Parameter** | **2gm Hay** | | | | | | |
| Time(Min) | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 |
| Volume (CC) | 3.5 | 5.8 | 6 | 9 | 11.3 | 13.4 | 15 |
| Mud cake thickness(mm) | 2 | | | | | | |

### 4.2. <u>Viscosity and Yield Point</u>

#### 4.2.1.Viscosity

A property of fluids and slurries that indicates their resistance to flow, defined as the ratio of shear stress to shear rate. Viscosity can be expressed mathematically as follows: Poise is the unit for viscosity, equivalent to dyne-sec/cm$^2$. Because one poise represents a high viscosity, 1/100 poise, or one centipoise (cp), is used for mud measurements. One centipoise equals one millipascalsecond. Viscosity must have a stated or an understood shear rate in order to be meaningful. Measurement temperature also must be stated or understood. Two viscosities that will be described in this research are plastic viscosity and apparent viscosity.

##### 4.2.1.1.Apparent Viscosity

The viscosity of a fluid measured at the shear rate specified by API. In the Bingham plastic rheology model, apparent viscosity (AV) is one-half of the dial reading at 600 rpm (1,022 sec$^{-1}$ shear rate) using a direct-indicating, rotational viscometer.

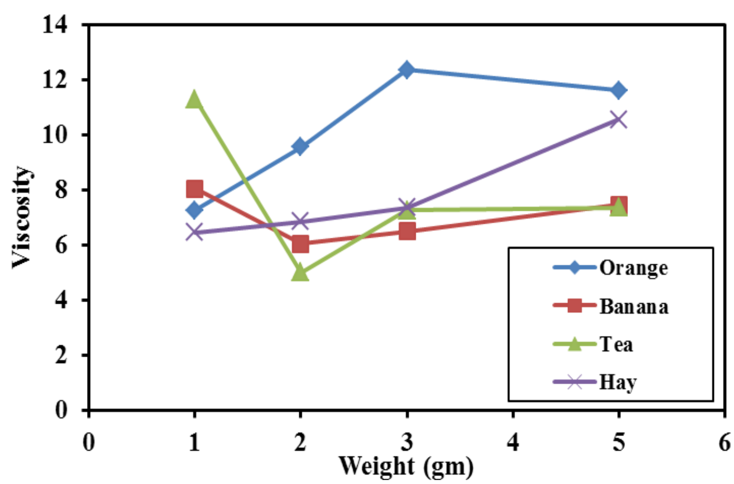



**Fig 4.2: Apparent Viscosity for Additives Materials**

The apparent viscosity in an orange peels additive is increased with the weight of the additive until it reaches 12.35 cP at 3 grams of orange peels this is the highest apparent viscosity and lowest apparent viscosity was 5 cP at 2 grams of tea residue.The apparent viscosity of other additives is between these two values. Show Fig4.2

### 4.2.1.2.Plastic viscosity

Plastic viscosity (Pv): This is a measure of the internal resistance to fluid flow attributable to the concentration, type, and size of solids present in a given fluid and the viscosity of the continuous phase. This value, expressed in centipoise, is proportional to the slope of the shear stress/ shear rate curve determined in the region of laminar flow for materials whose properties are described by Bingham's law of plastic flow. When using the direct-indicating viscometer, plastic viscosity is found by subtracting the 300-rpm reading from the 600-rpm reading. A low plastic viscosity indicates that the mud is capable of drilling rapidly because of the low viscosity of mud exiting at the bit High plastic viscosity can be caused by viscous base fluid and by excess colloidal solids. A reduction in solids content in order to lower plastic viscosity can be achieved by dilution.

### 4.2.2.Yield Point

The yield point represents the initial resistance to flow that caused by electrochemical forces between the particles in fluid phase. These electrochemical forces can be attributed to the charges on the surface of the particles that dispersed in fluid phase. The yield point property can be related to two main functions of drilling mud: Cleaning the hole and controlling the pressure drop through a fluid system. In other words, the carrying capacity of drilling mud increases with increasing itsyield point, but the circulation pressure through annulus will be decreased.

A higher yield point implies that drilling fluid has ability to carry cuttings better than a fluid of similar density but lower yield point. Yield point can be lowered by adding deflocculant and increased by adding flocculant.

The yield point to plastic YP/PV viscosity ratio of clay is very important, because it is an indicator of conditions of the drilling process. Turbulent flow is preferred in high angle wells for orifice cleaning. However, to ensure the strength of the clay gel is less important, because the carrying capacity is not affected by clay rheology. In the event that turbulent flow cannot be maintained, the YP/PV ratio should remain high Maybe. Also, if the hole measurement and well diameter expansion cannot be maintained, then the high YP/PV ratio is suitable for the slurry system. In laminar flow, the carrying capacity is affected with the rheological properties of clay. Therefore, 0when the YP increases to the viscosity of the plastic [YP/PV], the load increases Clay capacity increases.

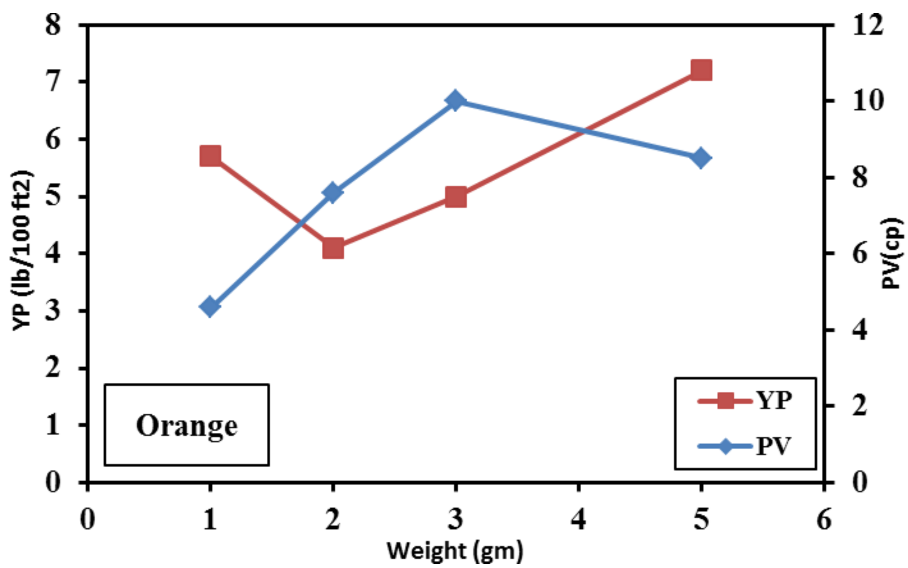



**Fig. 4.3: Fluid properties in orange peels additive**

In Fig4.3, as additives increase, plastic viscosity increases. The highest plastic viscosity value consists of adding 3 grams of orange peels, at which point the drilling fluid velocity is very low as it flows out of the drill bit and also, in yield point with the increase in the amount of additives, the yield point increases. The yield point in 5 grams of the additive is the highest value, and thismeans that at this stage it has sufficient strength to lift the excavated rocks to the surface.

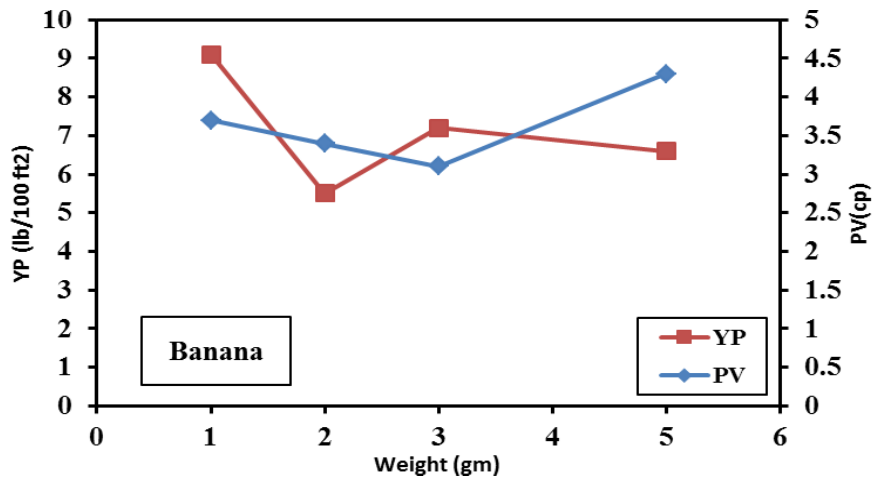



**Fig. 4.4: Fluid properties in Banana peels additive**

In the Fig4.4, plastic viscosity is much less compared to the Fig4.3. The minimum value is 3 grams of banana peels, meaning at this point the highest flow rate of the drilling fluid from the bit and yield point is less than the experience of orange peels, and all data indicates that the yieldpoint in this experiment is very little and the cleaning of the bottom of the well is few since liftingengraved pieces remain at the bottom.

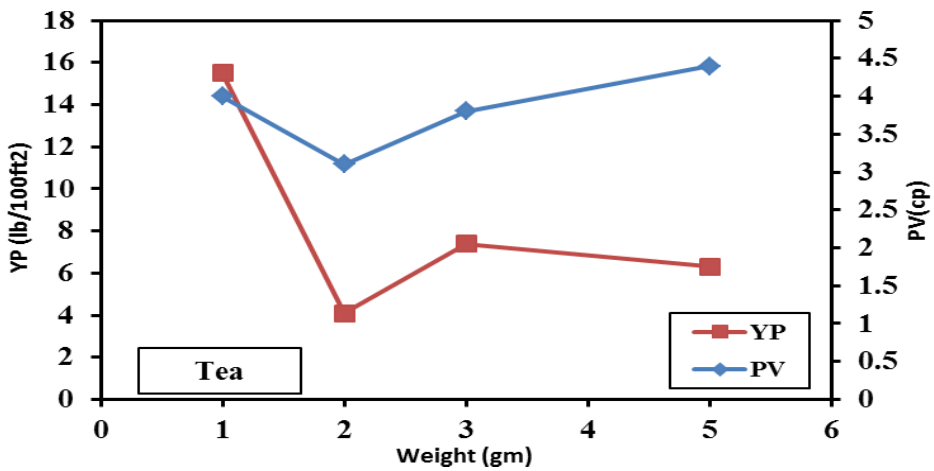



**Fig. 4.5: Fluid properties in tea residue additive**

A large decrease in the plastic viscosity in Fig4.5 explains this agitation material that has a low etching fluid flow velocity of a few bits. The Yield Point value in 3 grams of tea residue has enough force to lift rocks to the surface.

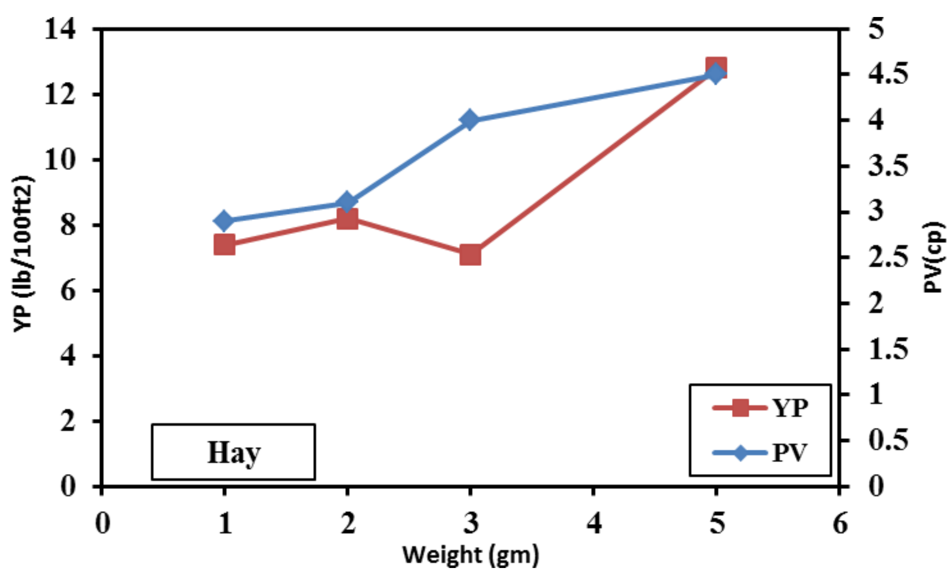



**Fig. 4.6 Fluid properties in hay additive**

In this Fig 4.6, we have a low viscosity and a high yield point meaning the flow velocity of the drilling fluid that comes out the bit High and powerful lifting of rock pieces to a high surface.

## 4.3. Gel Strength

The gel strength of drilling fluid represents the capability of the mud to keep the drilled cuttings in suspension in case of the circulation stopped. The gel strength is the shear stress measured at low shear rate after a mud has set quiescently for a period of time (10 seconds and 10minutes in the standard API procedure, although measurements after 30 minutes or 16 hours may also be made). Gel strengths are determined in the two-speed direct-indicating viscometer by slowly turning by hand the driving wheel on the top or side of the instrument and observing the maximum deflection before the gel breaks. Yield point is sensitive to the electrochemical environment; hence indicate the need for chemical treatment. The yield point may be reduced by the addition of substances neutralizing the electric charges such as thinning agent and by addition of chemicals to precipitate the contaminants. High viscosity resulting from high yield point is caused by introduction of soluble contaminant which interacts with negative charges on the clay particle, breaking of clay particles through mechanical grinding action creating new surface area of the particles and the addition of inert solids

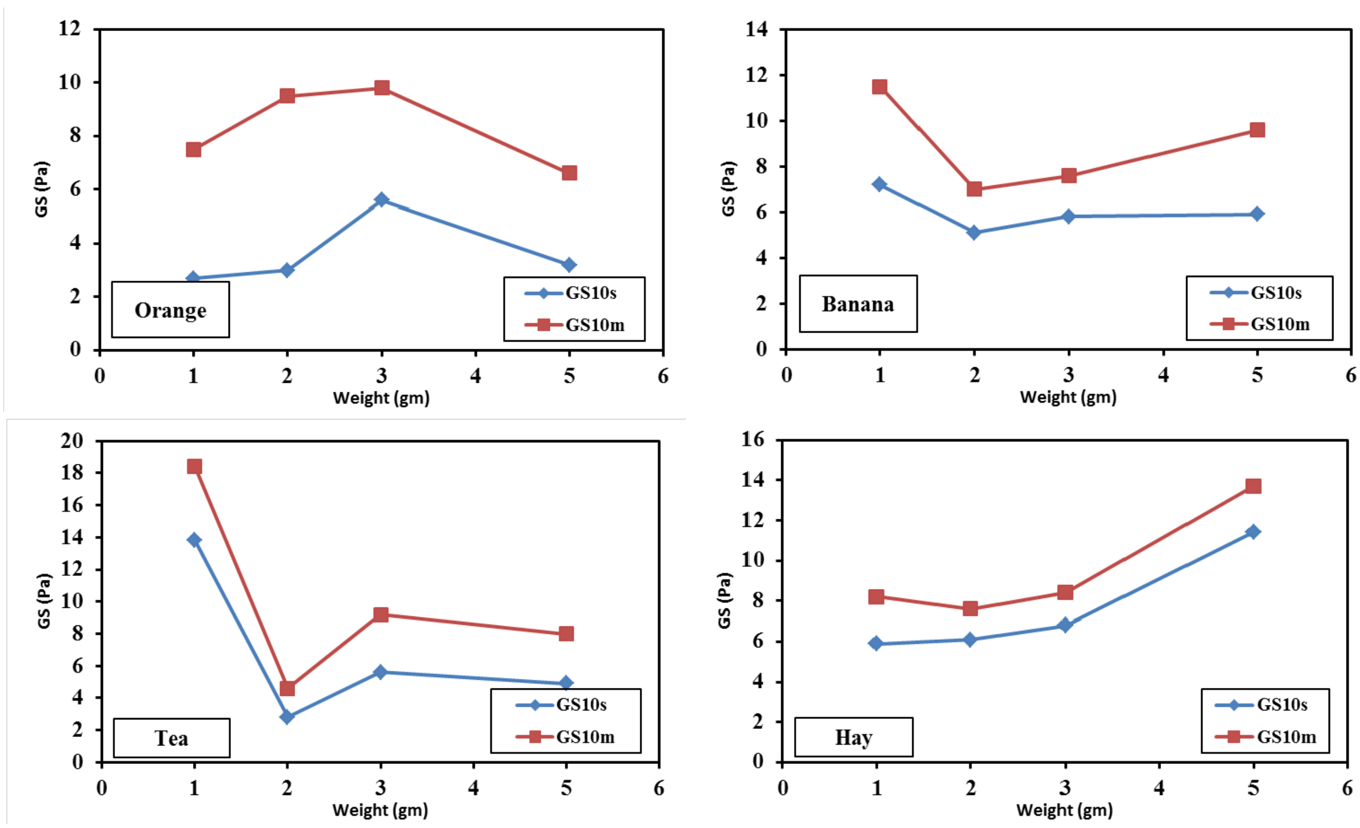



Fig 4.7: Gel Strength For All Additives Materials

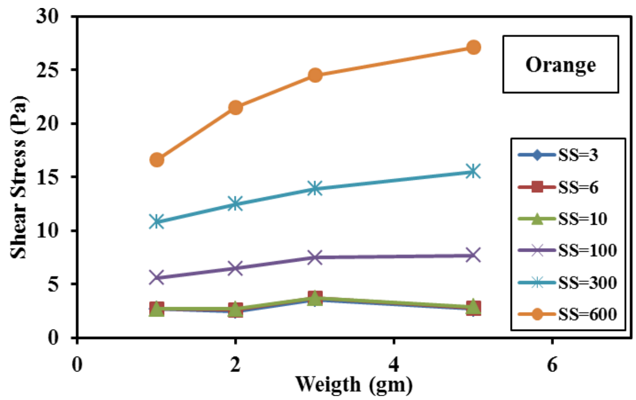
In the Fig4.7, the highest GS10sec 13.4Pa is from 5 grams of hay and the highest GS10min is 13.7 Pa from 5 grams of hay. The lowest **GS**10sec of 2.8 **Pa** is from 2 grams of tea residue and the lowest **GS**10min is 4.6 Pa from 2 grams of tea residue.

## 4. Shear stress (SS)

The shear stress exerted on the fluid is defined as the relationship between force F and area the force acts upon A

$$\tau = \frac{F}{A}$$

The relationship between shear strain and shear stress defines shear dependent viscosity of the material. If the material is a fluid, a constant force on the upper plate will result in a constant velocity u. The deformation, or flow, can be described by the time rate change of shear strain, also referred to as the shear rate.



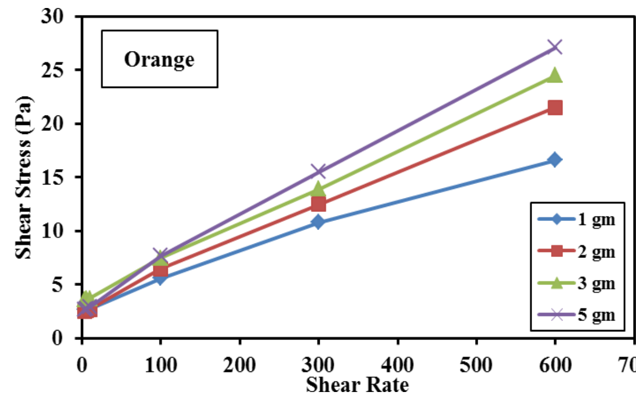
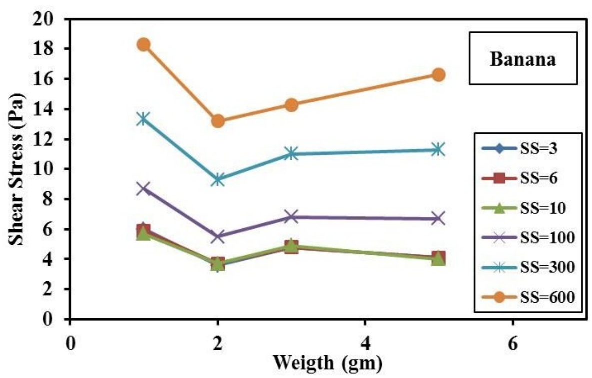




**Fig4.8: Shear strength change with the weight**

**Fig4.9: Shear strength change with the shear rate.**

In Fig. 4.8, orange peels additive shear stress increases with the weight of the orange peels. Lowest shear stress in this additive is 2.5 Pa at 2 grams. The highest shear stress compared to other additives at 600 is 27.1 Pa from 5 grams of orange peels Shear stress also increases with theshear rate the higher the shear rate the higher the shear stress as shown in Fig4.9.



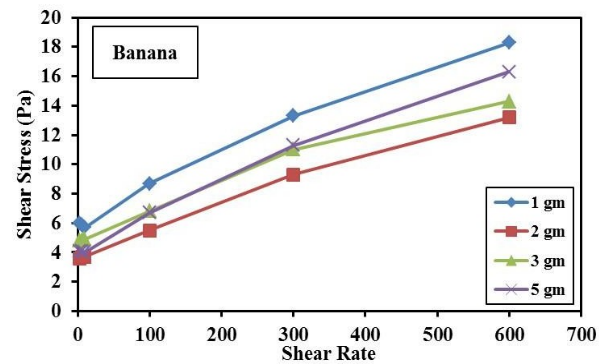
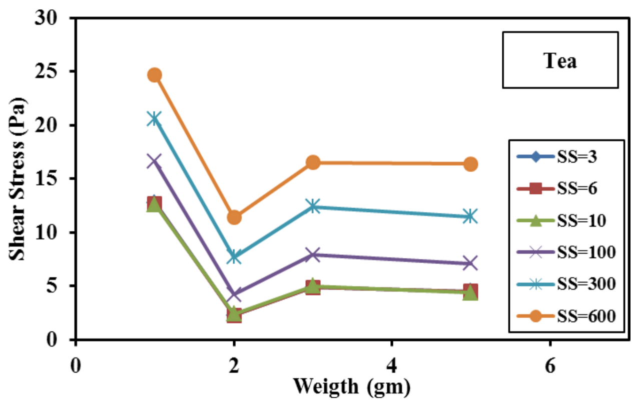




**Fig 4.10: Shear strength change with weight.**

**Fig 4.11: Shear strength change with shear rate.**

In the Fig 4.10, from this additive we have two cases: (1) In the beginning, the shear stress decreases with the increase in the amount of the additive (2) It starts with a little increase, but thisincrease is not affected, meaning that the best shear stress in this additive is in the weight of 1 gram of banana peels as shown in Fig 4.11, the highest shear stress with shear rate is in 1 gram of banana peels



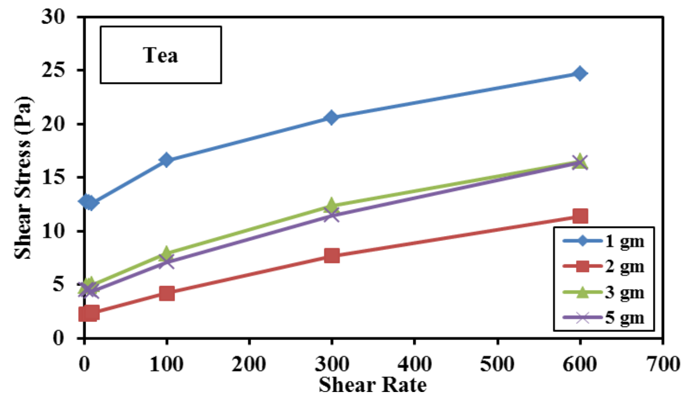
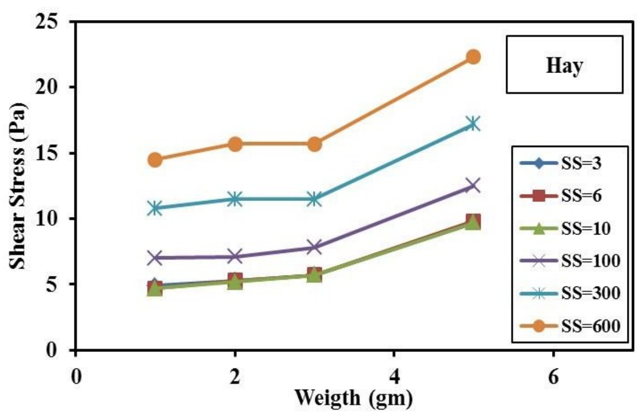




**Fig 4.12: Shear strength change with weight.**

**Fig 4.13: Shear strength change with shear rate.**

In Figure 4.12, this additive is close to this property that we showed earlier in Fig (4.10 - 4.11),and the lowest shear stress of all additives is from tea at SS=6 is 2.3 Pa. The highest shear stress is from 1 gram of tea residue and also the shear rate of 1 gram of tea residue is higher comparedto other weights of tea residue see Fig 4.13.



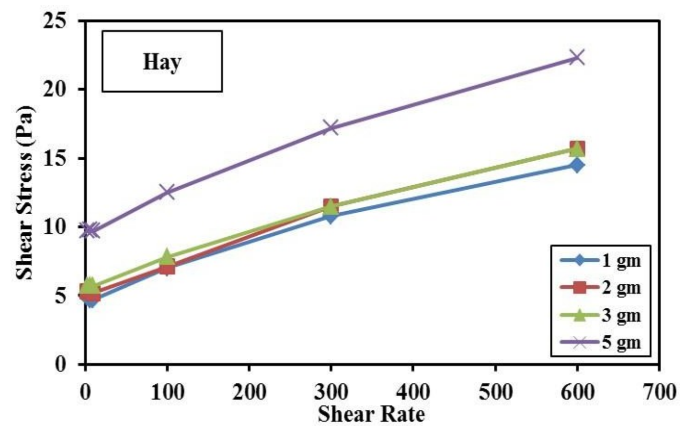




**Fig 4.14: Shear strength change with weight.**

**Fig 4.15: Shear strength change with shear rate.**

In Fig. 4.14: Shear stress increases with the weight of the additive, especially in 5g hay , which isthe highest of all measures. Shear stress increases as the shear rate increases. See Fig 4.15

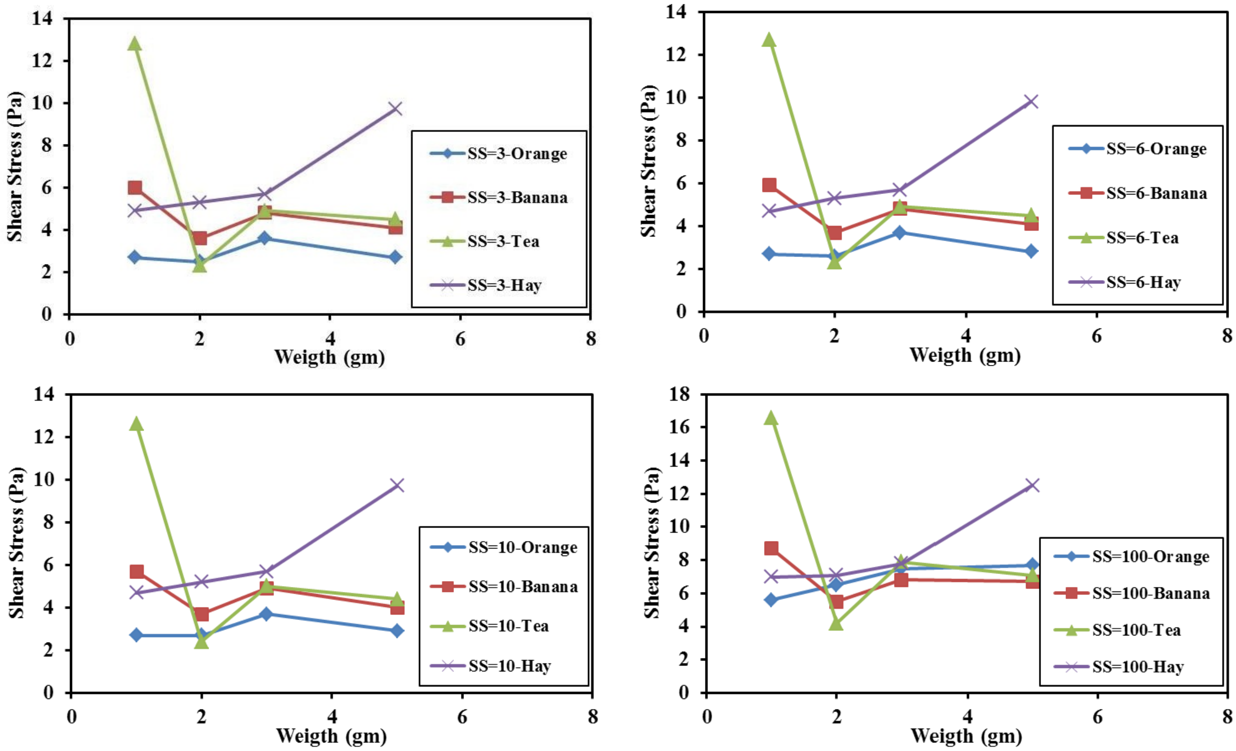



**Fig. 4.16. The shear stress change with the weight.**

In Fig4.16: both (SS=3,SS=6,SS=10,SS=100) shear stress initially decreases in additives of orange peels, banana peels and tea residue , and after increasing the amount of additive, shear stress increases, but very little, while in hay the shear stress increases with the increase in the amount of additive.

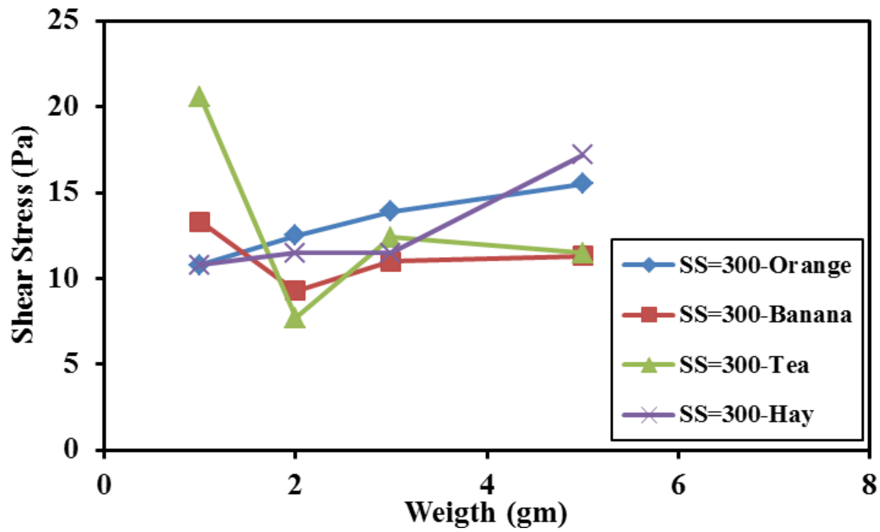



**Fig4.17: The shear stress change with the weight.**

In Fig4.17: the shear stress initially decreases in banana peels and tea residue additives, after increasing the amount of additive, the shear stress increases, but very little, while in hay the shearstress increases with the increase in the amount of additive and in orange peels the shear stress gradually increases well with the increase in the amount of additive added

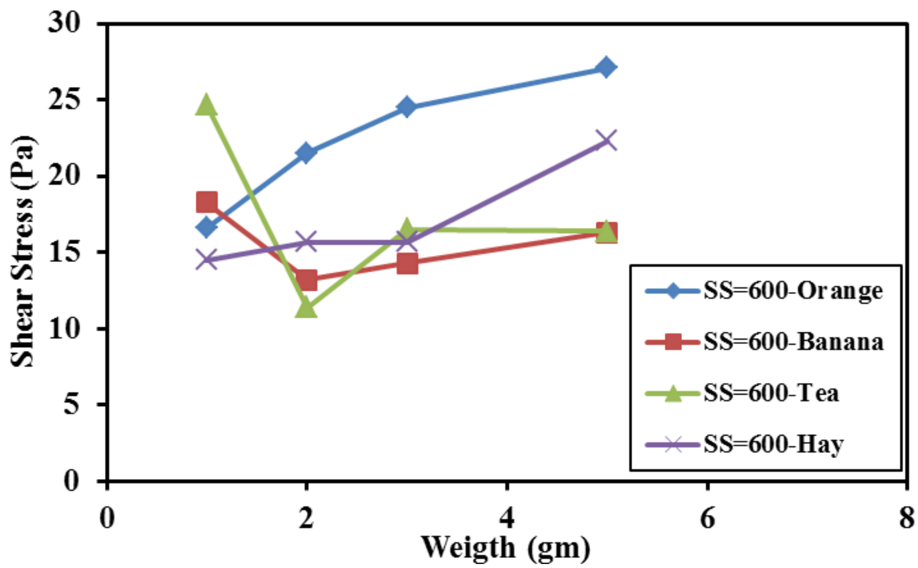



**Fig4.18: The shear stress change with the weight.**

In Figure 4.18, the high shear stress in oranges and the highest shear stress is 27.1Pa in 5 grams of oranges peels as we explained in the previous Fig4.17.

## 5. Shear Rate

The velocity gradient measured across the diameter of a fluid-flow channel, be it a pipe, annulus or other shape. Shear rate is the rate of change of velocity at which one layer of fluid passes overan adjacent layer. As an example, consider that a fluid is placed between two parallel plates that are 1.0 cm apart, the upper plate moving at a velocity of 1.0 cm/sec and the lower plate fixed. The fluid layer at the lower plate is not moving and the layer nearest the top plate is moving at 1.0 cm/sec. Halfway between the plates, a layer is moving at 0.5 cm/sec. The velocity gradient is therate of change of velocity with distance from the plates. This simple case shows the uniform velocity gradient with shear rate (v1 - v2)/h = shear rate = (cm/sec)/(cm/1) = 1/sec. Hence, shearrate units are reciprocal seconds.

Given the velocity ***du*** at the position ***dy*** the shear rate is :

$$\dot{\gamma} = \frac{d\gamma}{dt} = \frac{d}{dt}\left(\frac{dx}{dy}\right) = \frac{1}{dy}\frac{d}{dt}(dx) = \frac{du}{dy}$$

The shear rate is the same as the velocity gradient illustrated in Fig. 4.19. In other words, it is the rate of which the shear is applied on the fluid. All shear dependent fluids will change viscosity when exposed to different shear rates.

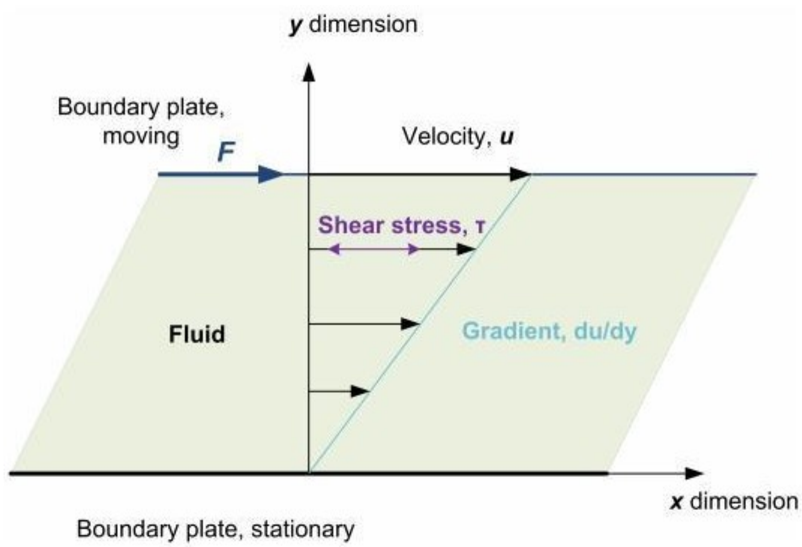



**Fig. 4.19 Flow between two parallel plates illustrating shear stress.**

As the shear rate increases, the shear stress increases in the form fig 4.20 from 1 gram of0 each additive and tea has the highest shear stress at all shear rates compared to other additives materials

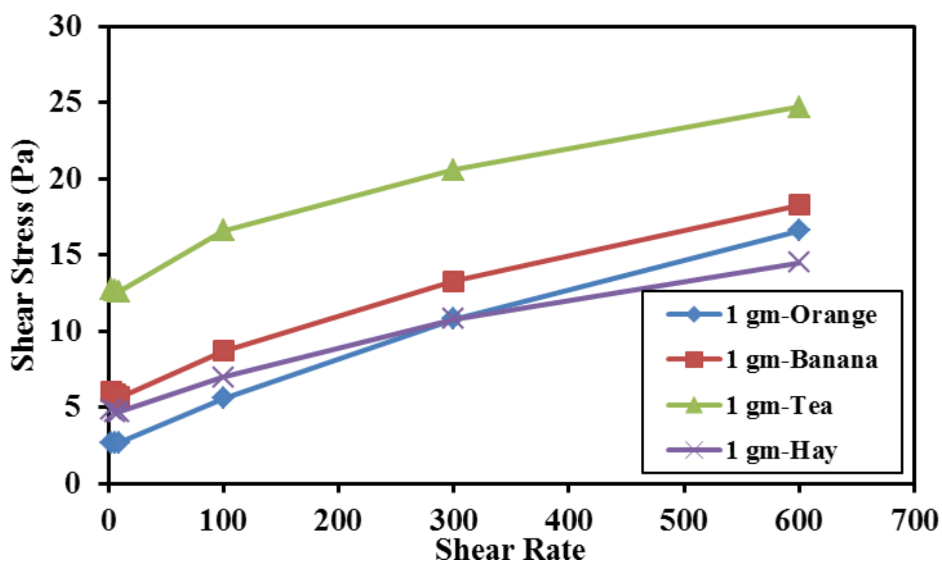



**Fig. 4.20: The shear stress change with the shear rate at 1 gm**

In Fig 4.21, at 2gm of each additive, there is a rapid increase in high shear stress of orange peels as shear rates increase and other additives increase but not like orange peels.

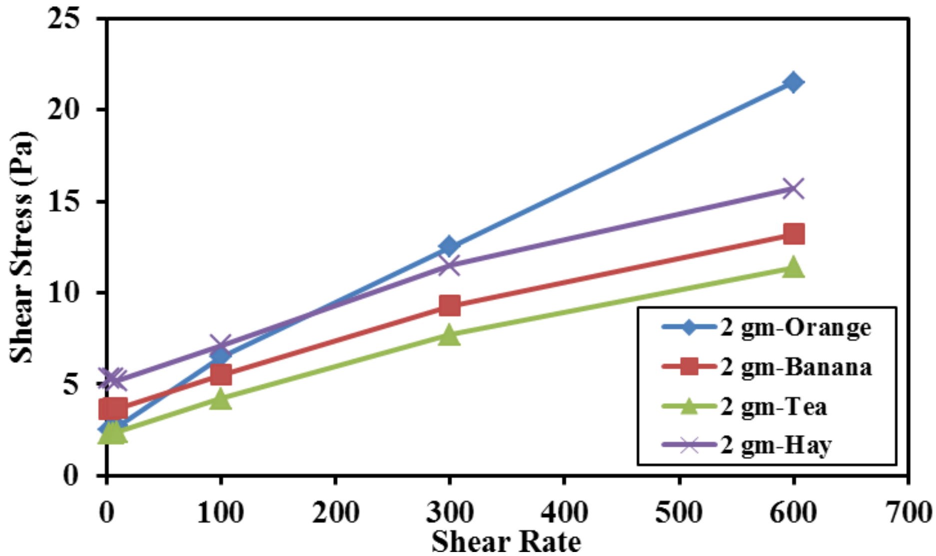



**Fig. 4.21: The shear stress change with the shear rate at 2 gm**

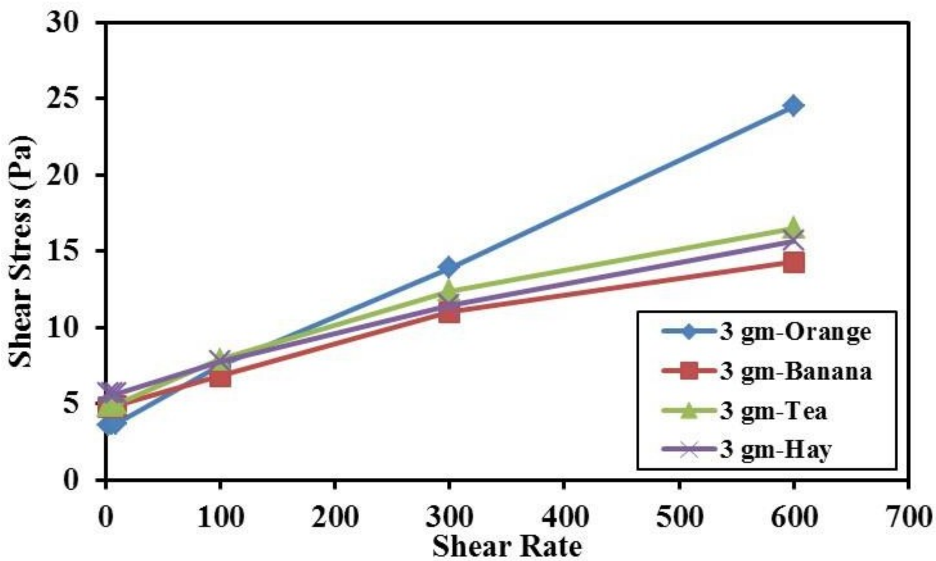



**Fig4.22: The shear stress change with the shear rate at 3 gm**

In Fig. 4.22, at 3 grams of both additives, the results of all components are close , except for oneadditive, which is orange peels, which increased more in shear stress with increasing shear rate, especially at shear rate 300 s-1 and above .

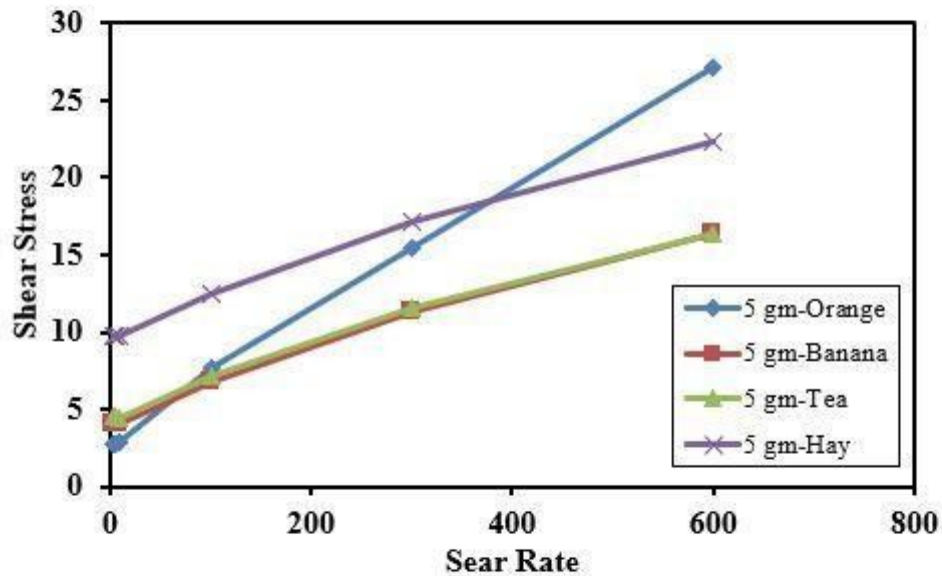



**Fig4.23: The shear stress change with the shear rate at 5 gm**

Changes in the increase in straw at 5g are second only to orange peel see Figure 4.23

**6. <u>pH</u>**

pH is a value representing the hydrogen ion concentration in liquid and it is used to indicate acidity or alkalinity of drilling mud. The pH is presented in a numerical value (0-14), which meansan inverse measurement of hydrogen concentration in the fluid. The pH formula is listed below; pH = -log10[H]

Where: H is the hydrogen ion concentration in mol.

According to the pH formula, the more hydrogen atoms present, the more acidity of substance is but the pH valve decreases. Generally speaking, a pH of 7 means neutral. Fluids with a pH above 7 are considered as being alkaline. On the other hand, the fluids with pH below 7 are defined as being acidic. In order to get accurate measurements for the pH, using a pH meter instead of using a pH paper is recommended because it will give more accurate pH figures. Additionally, pH meters must be calibrated frequently. And we explained the pH meter in chapter 3 Increasing thepH of the additives leads to Low plastic viscosity.

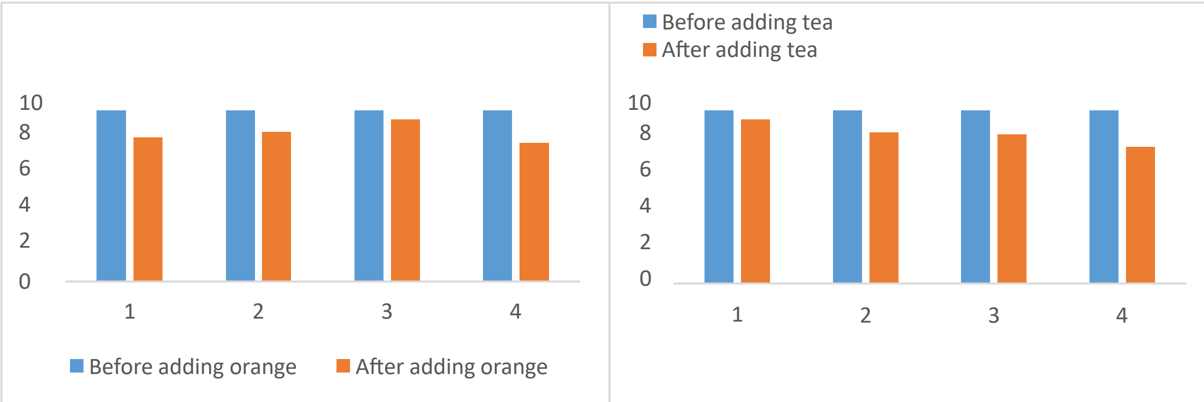



**Fig4.24: pH change with the weight.**

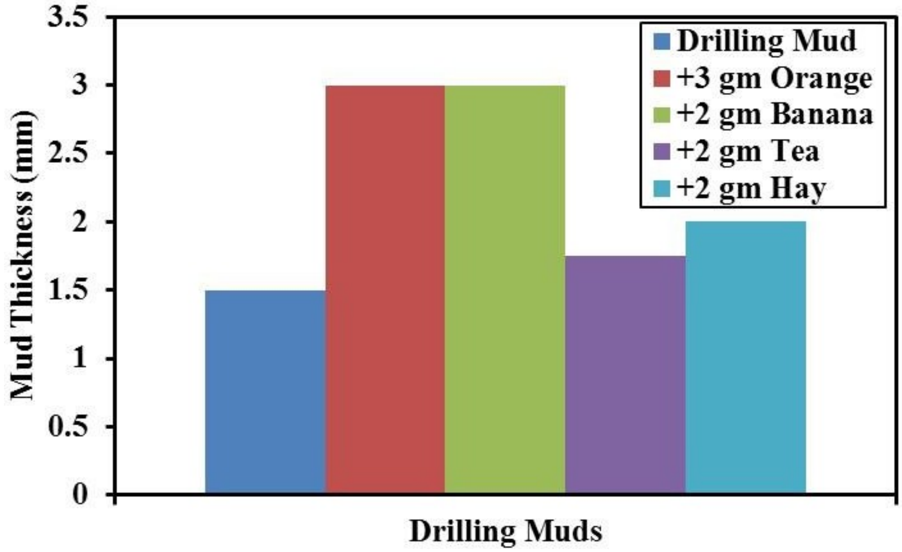
In fig4.24, It shows that the ph with the increase in the weight of the additive decreases in all the additives. The higher the ph after adding the additive is 9.1 of 1 gram of banana peels and the lowest pH is 7.5 of 5 gram of tea residue

## 7. <u>Filtration</u>

Mud filtration can be identified as the operation of allowing the liquid phase of the drilling fluids to pass through a permeable medium at certain differential pressures in which the liquid phase will be separated from the solid phase.

### 7.1. Mud filtrate (Mud Cake)

The liquid that passes through a filter cake from a slurry held against the filter medium, driven bydifferential pressure. Dynamic or static filtration can produce a filtrate.




. **Fig4.25: Mud cake thickness change with the type of drilling mud.**

The smaller the mud cake thickness, the better drilling fluid will be in Fig4.25, The minimum thickness of the mud cake is 1.75 mm which is from 2 grams of tea, and the top of the mud cakeis 3 mm which is from orange and banana.

## 7.2. Fluid loss

The leakage of the liquid phase of drilling fluid, slurry or treatment fluid containing solid particlesinto the formation matrix. The resulting buildup of solid material or filter cake may be undesirable, as may the penetration of filtrate through the formation. Fluid-loss additives are usedto control the process and avoid potential reservoir damage.

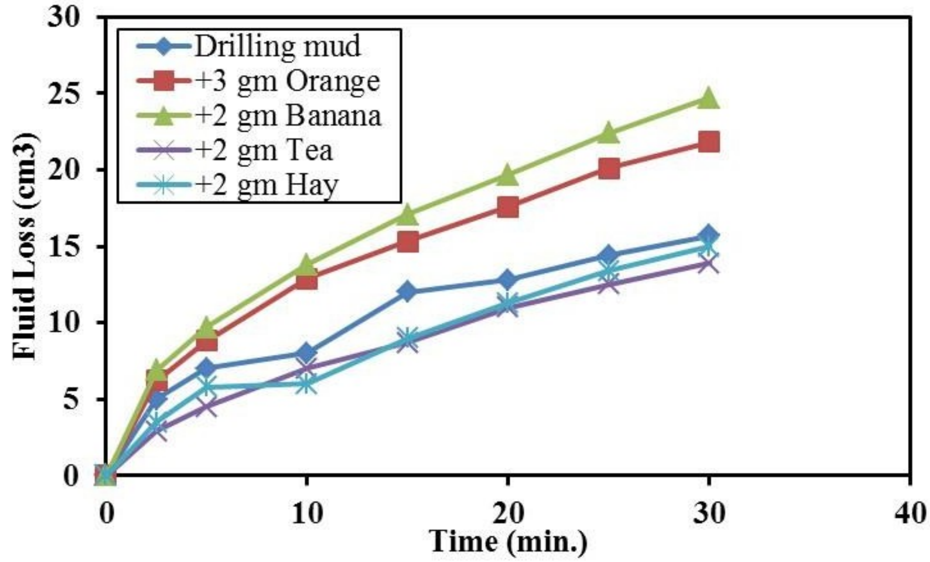



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**Fig4.26: Fluid loss change with the time.**

The lowest loss of drilling fluid is from tea residue, and after that, hay is ranked second, and the highest fluid loss is banana peels and orange peels , which is not desirable for drilling fluid WBM in drilling operations because of the large loss of drilling fluid see Fig4.26

- **Conclusions from chapter 4**

| DFP | Orange peels | | Banana peels | |
|---|---|---|---|---|
| | Max value 3(gm) 991 gm/bbl | Min value 1(gm) 331 gm/bbl | Max value 1(gm) 331 gm/bbl | Min value 2(gm) 660 gm/bbl |
| **PV(cp)** | 10 | 4.6 | 3.7 | 3.4 |
| **Yp (lb/100 ft²)** | 5 | 5.7 | 9.1 | 5.5 |
| **$\mu_a$ (cp)** | 12.35 | 7.25 | 8.05 | 6.05 |
| **GS(Pa) 10m** | 9.8 | 7.5 | 11.5 | 7 |
| **PH af** | 9 | 8 | 9.1 | 8.9 |

| DFP | Tea residue | | Hay | |
|---|---|---|---|---|
| | Max value 1(gm) 331 gm/bbl | Min value 2(gm) 660 gm/bbl | Max value 5(gm) 1651 gm/bbl | Min value 1(gm) 331 gm/bbl |
| **PV(cp)** | 4 | 3.1 | 4.5 | 2.9 |
| **Yp (lb/100 ft²)** | 15.5 | 4.1 | 6.6 | 7.4 |
| **$\mu_a$ (cp)** | 11.3 | 5 | 10.55 | 6.45 |
| **GS(Pa) 10m** | 18.4 | 4.6 | 13.7 | 8.2 |
| **PH af** | 9 | 8.3 | 8.2 | 9.1 |

# Chapter 5

## Conclusions and Recommendation

### 1. Conclusions

Experiments were conducted to examine the effect of Raw materials additives, with different concentrations to explore their effect to the drilling fluid rheological properties and filtration property. Based on the laboratory analysis the following conclusions can be made:

1. The improvement of rheological properties which had selected from raw materials additives, will assist in optimizing drilling process.
2. The highest value of the viscosity was at 3 grams of orange, The process of hole cleaning is done well, the lowest value of the viscosity was at 1 gram of hay, as the drilling process is faster as well as the case for 2 grams of tea residue and hay and 3 grams of bananas, these have a significant, impact on the hole cleaning and drilling durations.
3. The highest value of shear stress was at 5 gm orange peels, and the highest gel strength values wererecorded when using hay.
4. The best control for gel strength property Can get using hay raw material which Suspend cutting weight materials during static Period and ease of reales of gas.
5. The orange and banana raw materials will effectively use against seeping and partial losses as LCM.
6. The thickness of the mud cake at 2 grams of tea residue was the lowest for the rest of the materialsin the experiment, that can reduce the fluid loss, that will provide well bore stability and reduce the possibility of differential sticking.
7. The lowest loss of drilling fluid is from tea, and after that, hay is ranked second, which can effectively use against seeping and partial losses as LCM. But the highest fluid loss is banana and orange, which is not desirable for drilling fluid WBM in drilling operations because of the large loss of drilling fluid, which can’t effectively use as LCM.

8. With the increase in the weight of the additives, the pH of the material decreases. The highest value of YP was at 1gm tea. The lowest value of it was at 2gm orange peels and 2gm tea residue.

## 2. Recommendation

1. Using raw materials orange peels or tea peels or hay peels will effectively improves theologicalproperties of water based mud.
2. Formation damage system (FDS) test should be further analyzed by varying more particle size oflost circulation material used and quantity of lost circulation material added in drilling fluid.
3. Economic evaluation shall be conducted to compare the effectiveness of the formulation to be usedin the industry.

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