THE EFFECT OF USING DIFFERENT WEIGHTS OF CAUSTIC SODA ON THE WATER-BASE MUD DRILLING FLUID

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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Approved by,

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TRONOH, PERAK,

September 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgments and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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ABSTRACT

The main function of the drilling fluid is to keep the rotary drilling system working through the circulation of the fluid continuously down through the drill pipe, out through the bit nozzles and to the surface. The drilling fluid which is called the drilling mud can have several chemical and physical properties depending on the drilling process that is why we have different types of drilling fluids based on their compositions. This study concentrates on just one type of these drilling fluids which is water-base mud. The water-based mud drilling fluid systems are considered the most widely used system in the drilling operations due to its low cost comparing to the other types of the drilling fluid systems. The water base-mud is usually a mixture of water, clay and a few other chemicals such as the caustic soda which is the main concern of this study.

The caustic soda is the common name of the sodium hydroxide (NaOH). It is used in most of the water-based mud systems in order to control the PH value and the salinity of the drilling fluid system. During this study the main focus is on the effect of using different weights of caustic soda on water-based mud systems. As the drilling mud can be the first line of defense if any blow out occurs because it has a great effect on the pressure control that prevent any possibilities of loss of well control caused by formation pressure. So the rheology of the drilling mud is very important to identify the drilling mud ability to control the formation pressure. This study is conducted by using the mud balance test and the viscometer equipment on each mud sample to test the rheology. From the findings, the increase of using the weight of caustic soda in the Water-Base Mud drilling fluid leads to increase in the mud density, apparent viscosity, yield point values and the Gel strength values.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The major aspect that has a great influence on the rotary drilling system work is the ability of the drilling fluid to circulate continuously down through the drill pipe, out through the bit nozzles and back to the surface. A great advancement in drilling technologies are made to provide us with more effective and efficient drilling operations in deeper depths. The drilling fluid which is also called the drilling mud has a huge part of concern from these new technologies as it is very essential to the drilling operations by maximizing the hydrocarbon recovery. The drilling fluid in any drilling operation can be considered as the blood in the human body where the mud pump is the heart and the cuttings are the slag products. The drilling mud can have a wide range of chemical and physical properties. These properties are specially designed for drilling conditions and the special problems that must be handled in the drilling operation.

The drilling fluids have many purposes in any drilling operation which are,

- <u>Cooling and lubrication the drilling bits</u>. As the bit drills into the rock formation, the friction caused by the rotating bit against the rock generate heat. The heat dissipated by the circulating drilling fluid. This drilling fluid also lubricates the bit.
- <u>Cuttings removal.</u> An important function of the drilling fluid is to carry rock cuttings removed by the bit to the surface. The drilling flows through treating equipment where the cuttings are removed and the clean fluid is again pumped down through the drill pipe string.
- <u>Suspend cuttings.</u> There are times when circulation has to be stopped. The drilling fluid must have that gelling characteristics that will prevent drill cuttings from settling down at the bit. This may cause the drill pipe to be stuck.

- Pressure control. The drilling mud can be the first line of defense against a blowout or loss of well control caused by formation pressures.

- Data source. The cuttings that the drilling mud brings to the surface can tell the geologist the type of formation being drilled.

- Mud cake wall. The drilling fluid can wall the hole with impermeable filter cake. This will give a temporary support to the wall of the borehole from collapsing during drilling.

There are a lot of drilling process problems that can occur under different conditions and situations due to the wrong design of the drilling fluid. These problems can be solved by adding special materials to the drilling fluid to adjust its chemical or physical properties. In other cases due to the wrong design of the drilling fluid system, it may be necessary to replace the drilling fluid system that being used with another designed one. The most common changes in the drilling system could be the mud weight or the density that is why weighting materials are added when any pressure formations are expected. The most common problems that may occur due to the wrong drilling fluid system are,

- Lost circulation.
  It may happen in several types of formations, including high permeable formations, fractured formations and cavernous formations. Lost circulation materials can be added to the mud to bridge or deposit a mat where the drilling fluid being lost to the formation.

- Stuck pipe.
  It may occur after drilling has been halted for a rig breakdown, while running a directional survey or when conducting any non-drilling operations. The drill pipe may stick to the hole because of the formation of the filter cake or a layer of wet mud solids on the wall of the hole in the formation.

- Heaving or sloughing hole.
  This may occur when shale enter the wellbore after the section has been penetrated by the bit. By letting the mud in circulation when the drilling operation is suspended, this problem can be solved.

The drilling fluid is a mixture of water, oil, clay and various chemicals which contain in it. There are many different types of the drilling fluid systems. The major types of them are the water-base mud (WBM) and the oil-base mud (OBM). The water-base mud is the drilling fluid in which water is the continuous phase. On the other hand the oil-base mud is made up of oil as the continuous phase. This study concentrates on the water-base mud drilling systems as it is the most common drilling mud used in oil drilling. The usage of different weights of the caustic soda may have a change on the drilling fluid properties that is why this study shows the effect using different weights of the caustic soda which is a very important additive as a strong alkali in the water-base mud system.

1.2 Problem Statement

There is no early specific prediction on the behavior of the water-base mud drilling systems during the activity of the drilling operation while changing the weights of the caustic soda adding to the drilling fluid system. The composition of each ingredient in the water-base mud system depends on the actual requirements of the individual well. So, there is no specific universal standards of the ingredients in the drilling mud system which can be made for the entire wells in the reservoir. The drilling mud engineer has to choose the appropriate ingredients that should be used for each of the wells. As there is no reference table has been made related to different compositions of the drilling fluid systems, it encourages me to focus on one of the most important ingredient of the water-base mud drilling system which is the caustic soda to explain the influence of changing its weights in the system on the behavior of the water-base mud system and its chemical and physical properties.

1.3 Objectives

The major targets of this study are:

- To determine the effect of using different weights of the caustic soda (NaOH) in the water-base mud drilling systems on the rheology of the compositions before and after changing in the temperature.

- To investigate the effect of the usage of the different weights of the caustic soda in the water-base mud on the filtration behavior of the water- base mud before and after increasing the temperature.

1.4 Scope of Study

The drilling mud systems have a great importance in controlling the formation pressure down in the wellbore and building up a wall of a mud cake to reduce the possibility of the drilling fluid loss of circulation. This study focuses more on different compositions of water-base mud to be used in mud circulating system and the effect of changing the weights of the caustic soda in the compositions on the rheology of the compositions that affects directly the ability of controlling the formation pressure and the fluid filtration properties that has a direct influence on making the mud cake wall that helps in controlling the drilling fluid loss of circulation. The scope of this study is to make the rheology tests on the different compositions of the water-base mud with different weights of caustic soda to investigate its ability to control the formation pressure. And then, conducting the filtration test on the different compositions of the drilling mud samples to determine its ability to control the drilling fluid loss of the circulation through the process of building up the mud cake wall.

CHAPTER 2
LITERATURE REVIEW

The literature review will be focusing on all of the elements which are mentioned in this study in order to help in easily understanding this research.

2.1 Drilling fluids functions

The drilling fluids are considered one of the most important aspects in the drilling process of any well and it must have a careful design of its system to ensure a successful drilling operation with a minimum cost. The drilling fluid systems have a direct influence on the penetration rate and its response to weight on bit and rotary speed is highly dependent on the hydraulic horsepower reaching the formation at the bit. Since the drilling fluid flow rate sets the system pressure losses, and these pressure losses set the hydraulic horsepower across the bit, it can be concluded that the drilling fluid is as important in determining drilling costs as all other "man-controllable" variables combined. Considering these factors, "an optimum drilling fluid is a fluid properly formulated so that the flow rate necessary to clean the hole results in the proper hydraulic horsepower to clean the bit for the weight and rotary speed imposed to give the lowest cost, provided that this combination of variables results in a stable borehole which penetrates the desired target."

A properly designed drilling fluid system will enable an operator to reach the desired geologic objective at the lowest overall cost. A fluid should enhance penetration rates, reduce the borehole problems and minimize formation damage.

2.2 Major Functions

Drilling fluids are designed and formulated to perform three major functions:

- Control Subsurface Pressure
- Transport Cuttings
- Support and Stabilize the Wellbore

2.2.1 Control Subsurface Pressure

A drilling fluid controls the subsurface pressure by its hydrostatic pressure. Hydrostatic pressure is the force exerted by a fluid column and depends on the mud density and true vertical depth (TVD).

Borehole instability is a natural function of the unequal mechanical stresses and chemical interactions and pressures created when support in material and surfaces are exposed in the process of drilling a well. The drilling fluid must overcome both the tendency for the hole to collapse from mechanical failure and from chemical interaction of the formation with the drilling fluid. The Earth's pressure gradient is 0.465 psi/ft. This is equivalent to the height of a column of fluid with a density of 8.94 ppg, which is approximately the density of seawater. In most drilling areas, a fresh water fluid which includes the solids incorporated into the water from drilling subsurface formations is sufficient to balance formation pressures. However, abnormally pressured formations may be encountered requiring higher density drilling fluids to control the formation pressures. Failure to control the wellbore pressures may result in an influx of formation fluids, resulting in a kick, or blowout.

2.2.2 Transport Cuttings

Fluid flowing from the bit nozzles exerts a jetting action to clear cuttings from the bottom of the hole and the bit, and carries these cuttings to the surface. Several factors influence cuttings transport. If the cuttings generated at the bit face are not immediately removed and started toward the surface, they will be ground very fine, stick to the bit and in general retard effective penetration into uncut rock.

- Velocity: Increasing annular velocity generally improves cuttings transport. Variables include pump output, borehole size and drill string size.
- Density: Increasing mud density increases the carrying capacity through the buoyant effect on cuttings.
- Viscosity: Increasing viscosity often improves cuttings removal.
- Pipe Rotation: Rotation tends to throw cuttings into areas of high fluid velocity from low velocity areas next to the borehole wall and drill string.
- Hole Angle: Increasing borehole angle generally makes cuttings transport more difficult.

Drilling fluids must have the capacity to suspend weight materials and drilled solids during connections, bit trips, and logging runs, or they will settle to the low side or bottom of the hole. Failure to suspend weight materials can result in a reduction in the drilling fluid density which in turn can lead to kicks and a potential blowout.

2.2.3 Support and Stabilize Wellbore

Fluid hydrostatic pressure acts as a confining force on the wellbore. This confining force acting across a filter cake will assist in physically stabilizing a formation. Borehole stability is also maintained or enhanced by controlling the loss of filtrate to permeable formations and by careful control of the chemical composition of the drilling fluid.

Most permeable formations have pore space openings too small to allow the passage of whole mud into the formation. However, filtrate from the drilling fluid can enter the pore spaces. The rate at which the filtrate enters the formation is dependent on the pressure differential between the formation and the column of drilling fluid and the quality of the filter cake deposited on the formation face.
Large volumes of drilling fluid filtrate, and filtrates that are incompatible with the formation or formation fluids may destabilize the formation through hydration of shale and chemical interactions between components of the drilling fluid and the wellbore. Drilling fluids which produce low quality or thick filter cakes may also cause tight borehole conditions including stuck pipe, difficulty in running casing and poor cement jobs.

- Filter Cake: A layer of concentrated solids from the drilling mud which forms on the walls of the borehole opposite permeable formations.
- Filtrate: The liquid portion of the mud which passes through the filter cake into the formation.

2.3 Minor Functions

Minor functions of a drilling fluid include:

- Support Weight of Tubular
- Cool and Lubricate the Bit and Drill String
- Transmit Hydraulic Horsepower to Bit
- Provide Medium for Wire line Logging
- Assist in the Gathering of Subsurface Geological Data and Formation Evaluation
- Cool and Lubricate the Bit

2.3.1 Support Weight of Tubular

Drilling fluid buoyancy supports part of the weight of the drill string or casing. The buoyancy factor is used to relate the density of the mud displaced to the density of the material in the tubulars; therefore, any increase in mud density results in an increase in buoyancy.

2.3.2 Cool and Lubricate the Bit and Drill String

Considerable heat and friction is generated at the bit and between the drill strings and wellbore during drilling operations. Contact between the drill string and wellbore can also create considerable torque during rotation, and drag during trips. Circulating drilling fluid transports heat away from these frictional sites, reducing the chance of pre-mature bit failure and pipe damage. The drilling fluid also lubricates the bit tooth penetration through the borehole debris into the rock and serves as a lubricant between the wellbore and drill string thus reducing torque and drag.

2.3.3 Transmit Hydraulic Horsepower to Bit

Hydraulic horsepower generated at the bit is the result of flow volume and pressure drop through the bit nozzles. This energy is converted into mechanical energy which removes cuttings from the bottom of the hole and improves the rate of penetration.

2.3.4 Provide Medium for Wire line Logging

Air/gas-based, water-based, and oil-based fluids have differing physical characteristics which influence log suite selection. Log response may be enhanced through selection of specific fluids and conversely, use of a given fluid may eliminate a log from use. Drilling fluids must be evaluated to assure compatibility with the logging program.

2.3.5 Assist in the Gathering of Subsurface Geological Data and Formation Evaluation

The gathering and interpretation of surface geological data from drilled cuttings, cores and electrical logs is used to determine the commercial value of the zones penetrated. Invasion of these zones by the fluid or its filtrate, be it oil or water, may mask or interfere with the interpretation of the data retrieved and/or prevent full commercial recovery of hydrocarbon. Since the objective in drilling is to make and keep a borehole which can be evaluated for the presence of commercially-producible fluids, functions four and five should be given priority in designing a drilling fluid and controlling its properties. The conditions imposed by these functions will determine the type of drilling fluid system to be used in each borehole section and the products needed to maintain it. After the drilling fluid has been selected, the properties required to accomplish the first three functions can then be estimated by hydraulic optimization procedures.

2.4 Additional Benefits

In addition to the essential functions of a drilling fluid, there are other benefits to be gained from proper selection and control such as to:

- Minimize Formation Damage
- Reduce Corrosion
- Minimize Lost Circulation
- Reduce Stuck Pipe
- Reduce Pressure Losses
- Improve Penetration Rates
- Reduce Environmental Impact
- Improve Safety

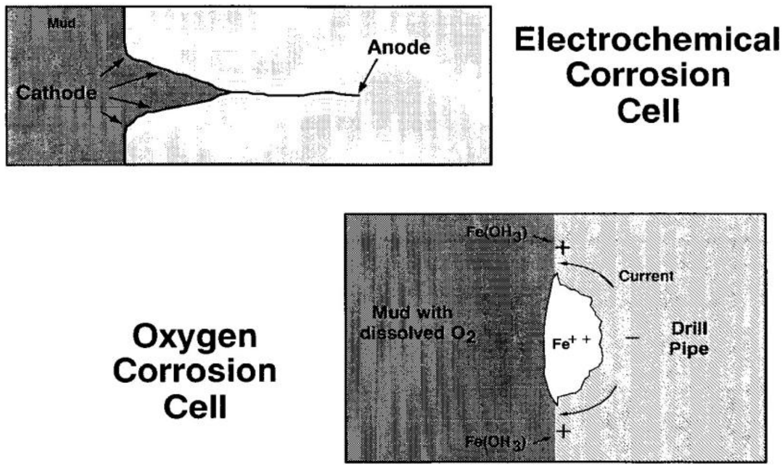
2.4.1 Minimize Formation Damage

A producing formation can be damaged by a poor drilling fluid. Damage mechanisms include formation fines migration, solids invasion, and wettability alterations. Identification of potential damage mechanisms and careful selection of a drilling fluid can minimize damage.

2.4.2 Reduce Corrosion

Corrosion control can reduce drill string failure through removal or neutralization of contaminating substances. Specific corrosion control products may be added to a drilling fluid; or the drilling fluid itself may be selected on the basis of its inherent corrosion protection as shown in (figure 2.1).

Figure 2.1
Electrochemical Corrosion Cell
(Development in a Fatigue Stress Crack)

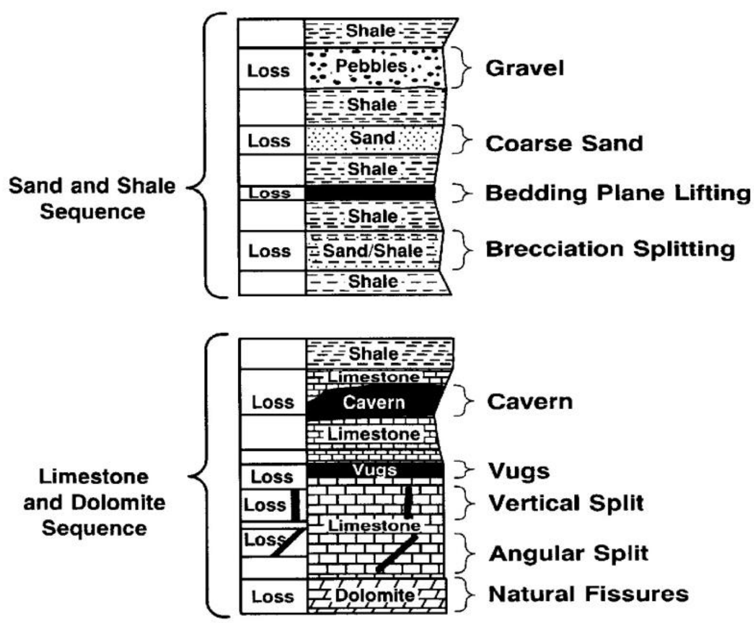


2.4.3 Minimize Lost Circulation

Extensive loss of whole mud to a cavernous, fissured, or coarsely permeable formation is expensive and may lead to a blowout, stuck pipe, or formation damage. Selection of a low density drilling fluid and addition of sized bridging agents can reduce lost circulation.

2.4.4 Reduce Stuck Pipe

Figure 2.2
Types of Lost Circulation Zones
Found in Soft and Hard Rock Formations



Pipe sticking can be caused by several factors:

- Poor Cuttings Removal
- Hole Sloughing
- Lost Circulation
- Differential Pressure Sticking

Figure 2.3

Differential Pressure

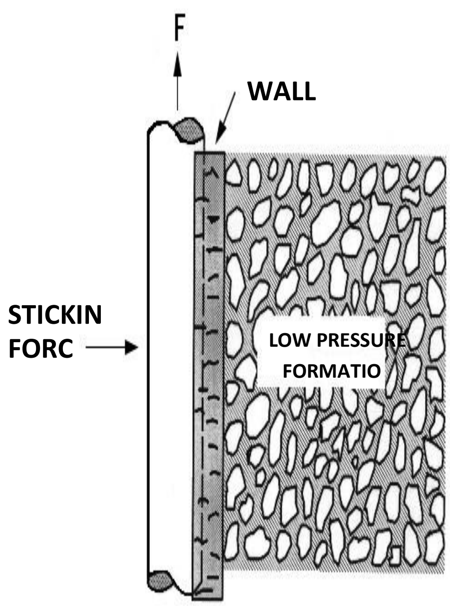
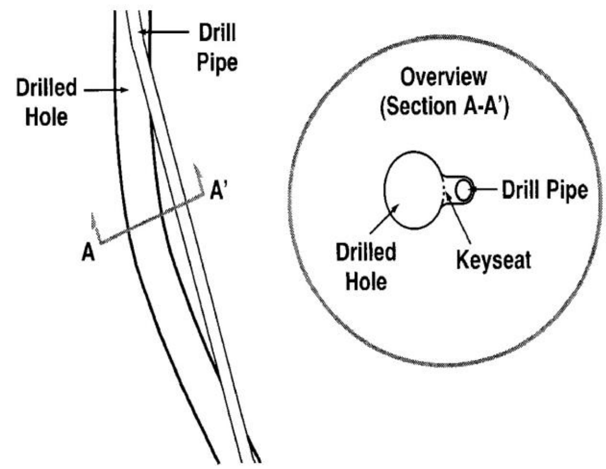


Figure 2.4
Key seating



Dog-Leg Resulting in the Formation of a Key seat

2.4.5 Reduce Pressure Losses

Surface equipment pressure demands can be reduced by designing a fluid to minimize pressure losses. The reduction in pressure losses also permits greater hydraulic efficiency at the bit and a lower equivalent circulating density (ECD).

2.4.6 Improve Penetration Rates

Proper fluid selection and control can improve the rate of penetration (ROP). Benefits of improved penetration rates are reduced drilling time and fewer borehole problems because of shorter open-hole exposure time. Generally, improved penetration rates result in reduced costs. Operations such as cementing, completion, and logging must be factored in to determine true cost effectiveness of improved penetration rates.

2.4.7 Reduce Environmental Impact

Fluid selection and engineering can reduce the potential environmental impact of a drilling fluid. In the event of a spill, reclamation and disposal costs, as well as pollution associated problems are greatly reduced by proper fluid selection and control.

2.4.8 Improve Safety

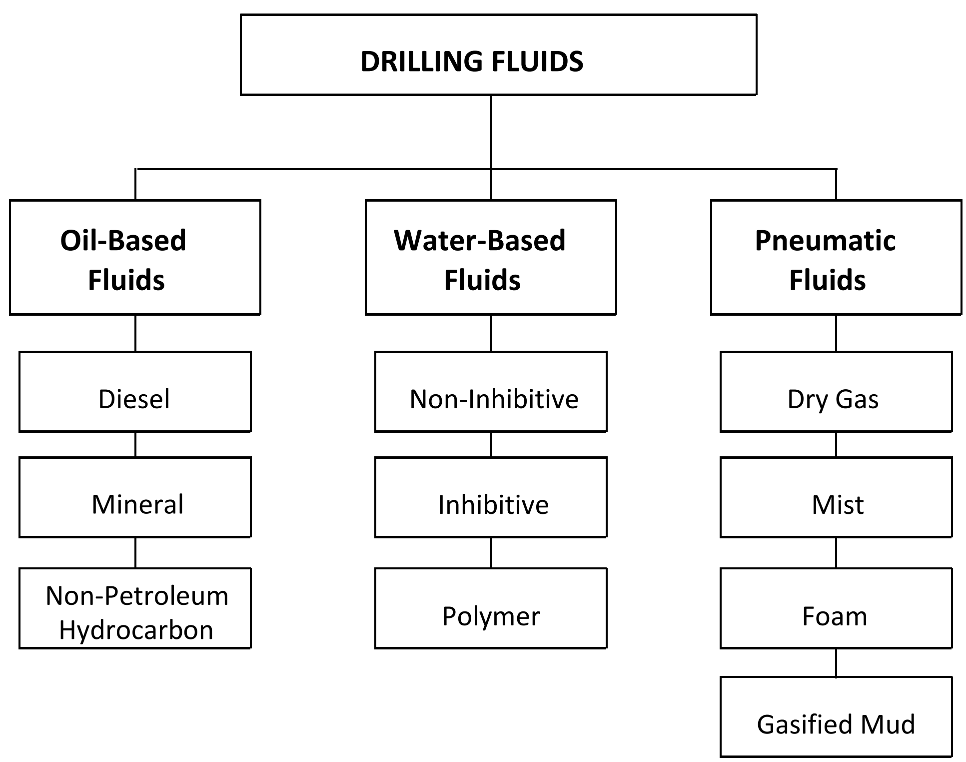
A drilling fluid should be engineered for safety. It should have sufficient density to control the flow of formation fluids and when circumstances merit, be able to tolerate toxic contaminants such as hydrogen sulfide (H_2S).

2.5 Drilling fluids classifications

The drilling fluid usually is a mixture of water, oil, clay, various chemicals like the caustic soda and other weighting materials. There are three major types or classifications of the drilling fluid as shown in (figure 5).

- Water-base Mud
- Oil-base Mud
- Pneumatic

Figure 2.5
Drilling Fluids Classification

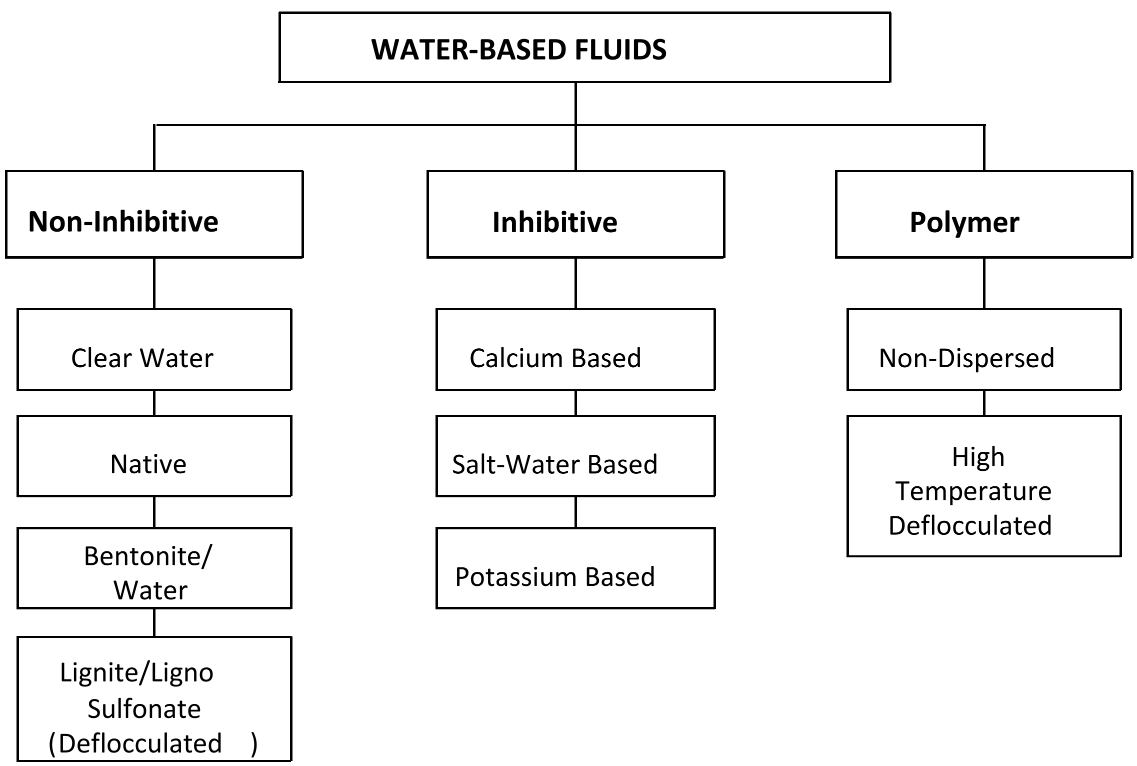


2.5.1 Water-base fluids

Water based fluids are the most extensively used drilling fluids. They are generally easy to build, inexpensive to maintain, and can be formulated to overcome most drilling problems. In order to better understand the broad spectrum of water-based fluids, they are divided into three major sub classifications:

- Inhibitive
- Non-inhibitive
- Polymer

Figure 2.6
Water-Based Fluids



2.5.1.1Non-Inhibitive Fluids

Those which do not significantly suppress clay swelling, are generally comprised of native clays or commercial bentonites with some caustic soda or lime. They may also contain deflocculants and/or dispersants such as: lignites, lignosulfonates, or phosphates. Non-inhibitive fluids are generally used as spud muds. Native solids are allowed to disperse into the system until rheological properties can no longer be controlled by water dilution.

2.5.1.2 Inhibitive fluids

Those which appreciably retard clay swelling and, achieve inhibition through the presence of cations; typically, Sodium (Na^+), Calcium (Ca^{++}) and Potassium (K^+). Generally, K^+ or Ca^{++}, or a combination of the two, provide the greatest inhibition to clay dispersion. These systems are generally used for drilling hydratable clays and sands containing hydratable clays. Because the source of the cation is generally a salt, disposal can become a major portion of the cost of using an inhibitive fluid.

2.5.1.3 Polymer Fluids

Those which rely on macromolecules, either with or without clay interactions to provide mud properties, and are very diversified in their application. These fluids can be inhibitive or non-inhibitive depending upon whether an inhibitive cation is used. Polymers can be used to viscosify fluids, control filtration properties, deflocculate solids, or encapsulate solids. The thermal stability of polymer systems can range upwards to 400°F. In spite of their diversity, polymer fluids have limitations. Solids are a major threat to successfully running a cost-effective polymer mud system.

2.5.2 Oil-Based Fluids

A primary use of oil-based fluids is to drill troublesome shale and to improve the borehole stability. They are also applicable in drilling highly deviated holes because of their high degree of lubricity and ability to prevent hydration of clays. They may also be selected for special applications such as high temperature/high pressure wells, minimizing formation damage, and native-state coring. Another reason for choosing oil-based fluids is that they are resistant to contaminants such as anhydrite, salt, and CO_2 and H_2S acid gases.

Cost is a major concern when selecting oil-based muds. Initially, the cost per barrel of an oil-based mud is very high compared to a conventional water-based mud system. However, because oil muds can be reconditioned and reused, the costs on a multi-well program may be comparable to using water-based fluids. Also, buy-back policies for used oil-based muds can make them an attractive alternative in situations where the use of water-based muds prohibit the successful drilling and/or completion of a well.

Today, with increasing environmental concerns, the use of oil-based muds is either prohibited or severely restricted in many areas. In some areas, drilling with oil-based fluids requires mud and cuttings to be contained and hauled to an approved disposal site. The costs of containment, hauling, and disposal can greatly increase the cost of using oil-based fluids.

2.5.3 Pneumatic Fluids

Pneumatic (air/gas based) fluids are used for drilling depleted zones or areas where abnormally low formation pressures may be encountered. An advantage of pneumatic fluids over liquid mud systems can be seen in increased penetration rates. Cuttings are literally blown off the cutting surface ahead of the bit as a result of the considerable pressure differential. The high pressure differential also allows formation fluids from permeable zones to flow into the wellbore.

2.6 Drilling Fluids Selection Criteria

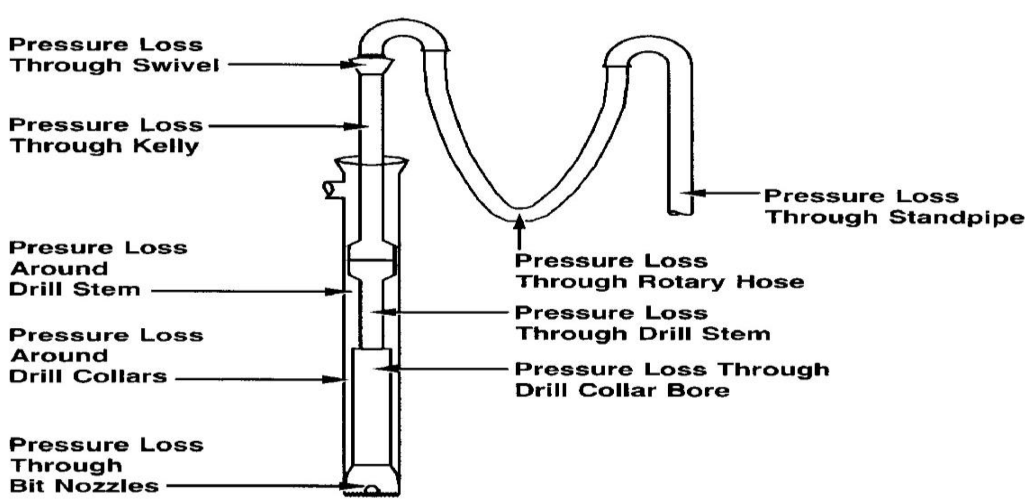
Drilling fluids are selected on the basis of one or more of the following criteria:

- Cost
- Application and Performance
- Production Concerns
- Logistics
- Exploration Concerns
- Environmental Impact and Safety

2.6.1 Cost

A traditional focus for drilling fluids selection is cost. However, there are other equally important factors such as total well cost and the fluid's effect on well productivity.

Figure 2.7
Pressure Losses in a Circulating Mud System



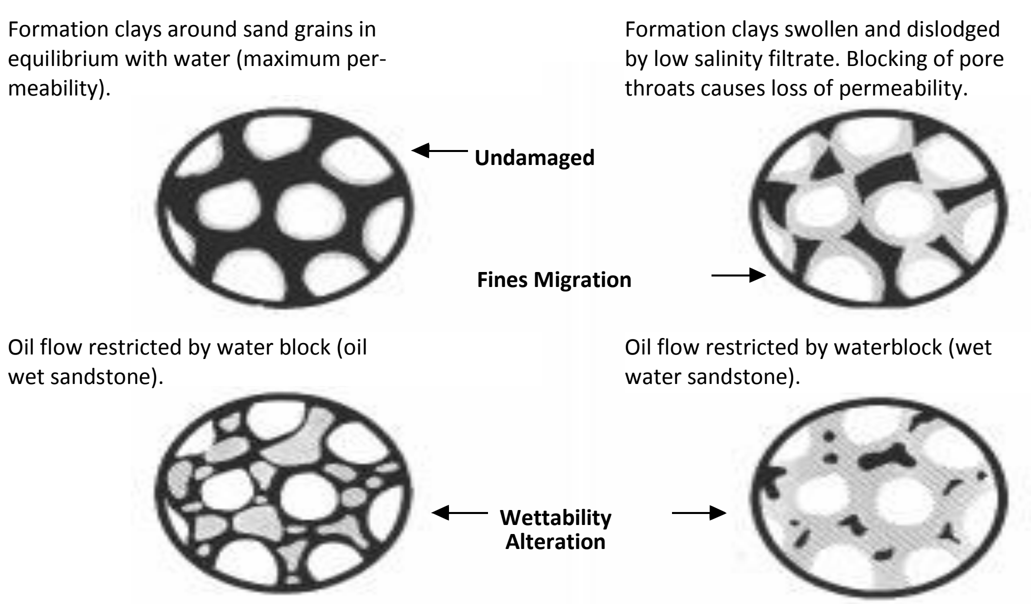
2.6.2 Application and Performance

Drilling fluid systems should be selected to provide the best overall performance for each specific well. Historical data should be reviewed and pilot testing performed to assure the greatest hole stability and lowest total well cost are achievable.

2.6.3 Production Concerns

Production personnel are primarily concerned with minimizing formation damage. Drilling fluid/formation interactions and other processes which alter in situ formation characteristics must be considered in the selection of additives and fluid systems. Production zones can be partially or totally lost depending upon fluids selected to drill and/or complete a well (see Figure 8).

Figure 2.8
Types of Formation Damage



2.6.4 Logistics

Logistics is a major consideration in well planning and mud program development when operating in remote areas. Product efficiency, shelf life, packing, transportation costs, warehousing, and inventory volumes should also be considered.

2.6.5 Exploration Concerns

The geologist's concern with drilling fluids and additives is centered on the effect of the drilling fluid on cuttings analysis and log interpretation. Extended gas chromatography and pyrolysis provide geological personnel with distinct fingerprints of hydrocarbons present and a means of isolating and identifying source rocks and oil migration paths. Unfortunately, trace amounts of drilling fluid may remain on the residue extracted from the cuttings and exert a masking effect that makes it difficult to accurately characterize (fingerprint) the formation hydrocarbons. Therefore, characterizing and cataloging drilling fluid additives and fluid systems can greatly enhance the geologist's interpretation of reservoir potential.

2.6.6 Environmental Impact and Safety

Minimizing the environmental impact of a drilling operation as well as safety considerations both directly affect the choice of drilling fluid additives and drilling fluid systems. Products that have been used in the past may no longer be acceptable. As more environmental laws are enacted and new safety rules applied, the choices of additives and fluid systems must also be reevaluated. To meet the challenge of a changing environment, product knowledge and product testing become essential tools for selecting suitable additives and drilling fluid systems.

2.7 Other Considerations of the Drilling Mud Selection

There are other considerations that must be taken into account when selecting drilling muds to drill a well such as well type, problem formations, drilling rig, producing formations and kind of production, casing program, makeup water, potential corrosion, environmental impact, and availability of products in international operations.

i) Well type – Choosing between development or wildcat well drilling. Different types use different types of drilling muds.

ii) Problem formations – Shale formations, anhydrite formations, salt formation, high-temperature formation, abnormal pressure formation and inherently fractured formation use different types of muds as well.

iii) Shale intervals – OBM is widely used in shale formation. But, due to the mechanical pipe sticking, high torque/drag, annular hole-cleaning difficulties, logging difficulties and mud contamination, drilling in the shale gives these probable problems. Different types of OBM deal with these kinds of problems.

iv) Anhydrite intervals – Mainly involves use of WBM. Different concentrations of WBM affect the mud viscosity and fluid loss to different types of anhydrite formations. Proper assessment needs to be done to select the best WBM used.

v) Salt intervals – Contamination of bentonite-treated freshwater fluids from the drilling of salt sections has effects similar to those of the anhydrite formations. Contaminating ions can be magnesium, calcium, or chloride ions. To mitigate this problem, the treatment of ions by using different concentrations of WBM is implemented.

vi) High-temperature formation – Wellbore temperatures in excess of 250°F generally reduce the effectiveness of drilling-fluid chemical additives and thus can result in changes to such fluid properties as viscosity and fluid loss. Tolerant-to-high-temperature mud is selected to solve this problem.

vii) Abnormal pressure formation – Abnormal pressures result in intrusion of formation fluids into drilling muds, resulting in mud contamination and undesirable kicks.

Proper selection of mud weight and suitable formation pressures can alleviate this problem.

viii) Loss circulation zones – Loss circulation zone is a formation interval that allows whole drilling fluid to be lost into the zone. If only part of the whole mud is lost, then the interval is called partial-loss circulation zone while total loss of circulation happens when no mud return to the surface.

ix) Producing formation – Minimum fluid filtrate in formations that are intended to be zones for oil/gas production will has no adverse effects on the producing formations.

x) Drilling rig – Success of a mud program in achieving optimum drilling is predicated on the proper selection of the rig and its layout.

xi) Casing program – Well-designed drilling mud will minimize casing-setting requirements and thus reduce well costs. For instance, changes in lithology and isolation of troublesome formations are typical requirements for setting casing at designated depths.

xii) Makeup water and availability – Primary considerations in the selection of the mud programs are source and the chemical composition of the makeup water. Availability and source of the makeup water must be considered so that mud treatment cost can be minimized. For example, freshwater is abundant on location, then mud dilution may be the most economical treatment.

xiii) Corrosion – Presence of dissolved gases in drilling muds decreases the life expectancy of drill pipe significantly. Drill pipe failure occurs at any applied cyclic stress if the number of fatigue cycles becomes sufficiently large. xiv) Environmental impact – Mineral-oil-based or synthetic-oil-based mud systems are universally selected over the conventional diesel oil-based system when environmental impact involves.

2.8 Advantages and Disadvantages of WBM and OBM

Table 2.1: Advantages and disadvantages of WBM and OBM

Drilling Mud	Advantages	Disadvantages
WBM	• No use of hydrocarbons which reduces impact on environment • Easy to control viscosity • Easy to control density for low pressure formation well drilling • Drill chips easier removed from fluid at shakers	• Not as efficient lubricant as OBM • Can promote corrosion to drill bit • Not efficient at high temperatures • Does not carry cuttings to the surface as efficient as OBM.
OBM	• Improved lubrication and anticorrosive properties • Maintains formation at high temperatures	• Can cause toxic fumes that affect the drilling team • Can be very high density/pressure and cause damage to well bore/surrounding formation

Based on the information of table 1, it is clearly shows that both WBM and OBM have their own advantages and disadvantages. WBM is mainly used at low pressure well drilling while OBM is used at high temperature and high pressure well formation.

2.9 drilling mud properties

i) Viscosity – Internal resistance of a fluid to flow. This is attributed to the attraction between molecules of a liquid and is a measure of the combined effects of adhesion and cohesion on suspended particles and the liquid environment.

ii) Density (mud weight) – Ideally, a mud weight as low as the weight of water is desired, for optimum drilling rates and for minimizing the chances of fracturing the formation. However, in practice, mud weights in excess of two times the weight of water may be necessary, to contain abnormal pressures or to mechanically stabilize unstable formations.

iii) pH – hydrogen ion concentration, is a measure of the relative acidity or alkalinity. pH of mud plays a major role in controlling the solubility of calcium. High pH values of drilling mud are suitable to use at carbonate formations, which normally are susceptible to erosion and dissolution by freshwater mud. pH also important indicator for the control of corrosion.

iv) Rheology – Study of deformation fluids. It is the basis for all analyses of wellbore hydraulics.

v) Plastic viscosity – Part of the flow resistance of the fluid caused by mechanical friction within the fluid. This mechanical friction is due to the interaction of individual solid particles, the interaction between solid and liquid particles, and the deformation of the liquid particles under shear stress.

vi) Yield stress – Part of the flow resistance of the fluid caused by electrochemical forces within the fluid. These electrochemical forces are due to the electrical charges on the surface of reactive particles, the electrical charges on the submicron particles, and in WBM, the presence of the electrolytes.

vii) Gel strength – Measurement of the electrochemical forces within the fluid under static conditions.

2.10 The Caustic Soda

The caustic soda is known as the sodium hydroxide (NaOH). It is considered as a strong corrosive substance and a strong alkali. It has many types depending on its quality such as:

- Crystalline caustic soda contains 70% to 75% of (NaOH).
- Caustic soda anhydrous contains more than 95% of (NaOH).

The caustic soda has different shapes like:

- White crystalline powder
- White spherical shapes, flaxes or white powder.

It is colorless and transparent. It reacts with various acids such as hydrochloric acid generating considerable exothermic heat of neutralization. It corrodes metals such as aluminum. It can be delivered in 48% solution (liquid caustic soda) and 98% in solid form of flake caustic soda.

2.11 The usage of the caustic soda

Oil and gas industry uses caustic soda in many operations such as the exploration, production and the processing operations of the petroleum and the natural gas. It is used to remove acidic materials from hydrocarbons and off-gas, as it adsorbs carbon dioxide in light petroleum fractions. It is used as a cleaning element, as it is used as anti-corrosion device in the pipeline system. it also used as a treatment step in the removal of various sulfur compounds, as for the poor quality crude oil, the caustic soda can be used to remove sulfurous impurities in a process known as caustic washing. As mentioned before, the (NaOH) reacts with weak acids such as H2S to give non-volatile sodium salts which can be removed. The caustic soda dissolves in water solution so it is used as a cleaning agent because it can easily absorbs gases like H2S and CO2.

The caustic soda is also used in the production operation as an additive in the drilling mud which is the main concern of this study in order to increase the alkalinity in bentonite the mud systems and to increase the mud viscosity to neutralize any acid gas like H2S or CO2.

CHAPTER 3

METHODOLOGY

This project emphasizes the influence of the usage of different samples of different weights of the caustic soda on the water-base mud drilling fluid through many laboratory experiments.

3.1 Laboratory Experiments

This study concentrates more on different samples of water-base mud drilling fluids with different weights of the caustic soda. This study is divided into three stages of lab experiments which are:

- The rheology tests for each mud sample to test the mud weight or the mud density.
- The FANN Viscometer tests to determine the GEL strength, plastic viscosity and the apparent viscosity.
- The filtration test to determine the filtration properties of each of the mud samples.

These tests are done in the drilling mud laboratory in block 15 at Universiti Teknologi PETRONAS.

figure 3.1: The laboratory experiments sequence

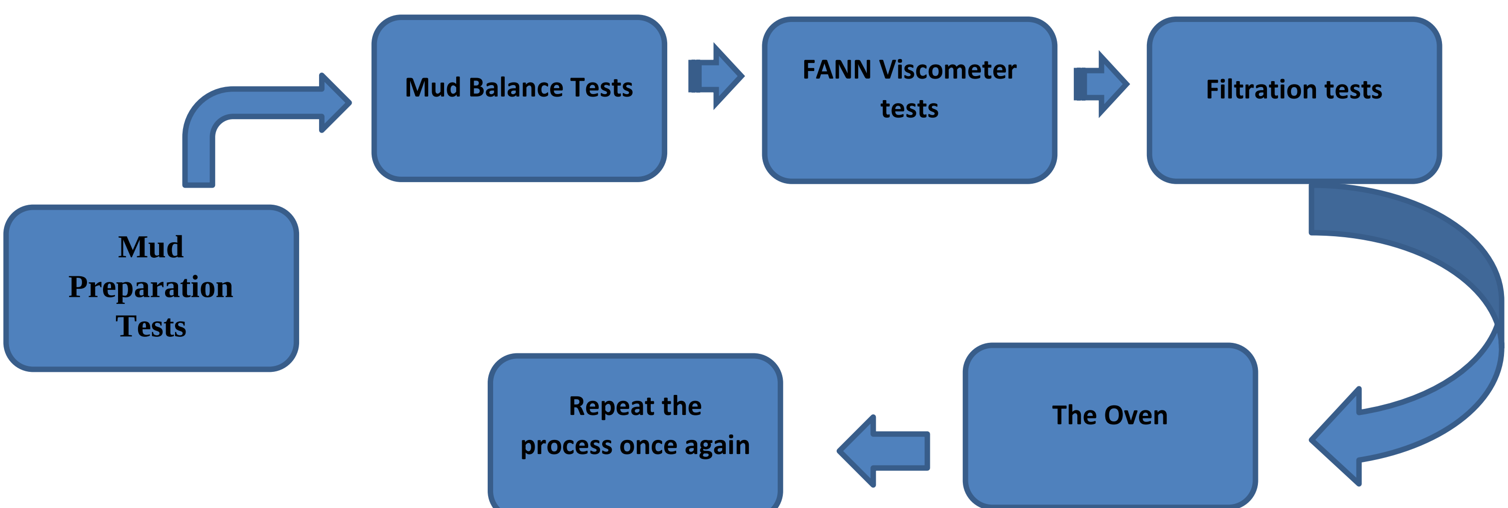
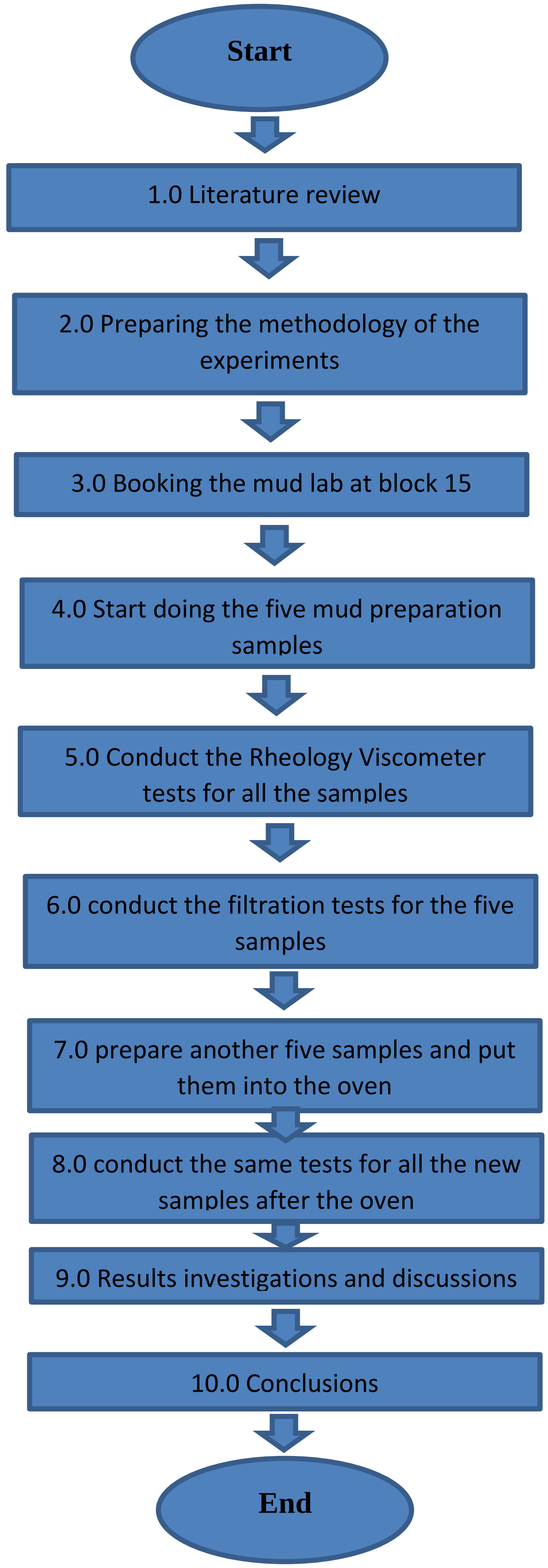


Figure 3.2: illustrates the flow chart that has been used throughout the research.



3.2 materials preparation

In mud preparation, each drilling muds will be examined and tested on mud weight or density test, rheology, gel strength, plastic viscosity, and apparent viscosity. The tools that will be used in this experiment are mud balance and FANN Viscometer.

Viscometer (Figure 11) is used to determine the plastic viscosity, apparent viscosity, yield point, and gel strength while mud balance (Figure 12) is used to determine the mud density. The compositions of the WBM are collected from past studies which tested the Rheology of the drilling muds. All mud samples will be prepared with reference to American Petroleum Institute API Series 13 Standard. Mud samples will be prepared in the Drilling Laboratory at Universiti Teknologi PETRONAS at Block 15. The composition of the drilling fluids will be different for each mud sample based on its different weight of the caustic soda added to them in order to investigate the effect of changing the weights of the caustic soda in the compositions on its ability to control the formation pressure and to the stability of the wellbore due to the buildup of the mud cake wall.. The composition of the muds are shown in Table 2 and 3.

The materials used to conduct these laboratory experiments are:

- Mud Balance
- FANN Viscometer
- API Filter Test (LPLT)
- The Oven

3.2.1 Mud Preparation

Water-Base mud (WBM)

Table 3.1: Samples of WBM

MUD # ID	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE#5
Water (ml)	330	330	330	330	330
Soda Ash (g)	0.3	0.3	0.3	0.3	0.3
Caustic Soda (g)	0.2	0.4	0.6	0.8	1.0
Calcium Chloride (g)	45.0	45.0	45.0	45.0	45.0
Calcium Carbonate (g)	20.0	20.0	20.0	20.0	20.0
Barite (g)	68.0	68.0	68.0	68.0	68.0

Below are the procedures to prepare the five samples of the Water-Base Mud (WBM)

1. The materials in Table 3.1 were prepared first.
2. Soda ash, potassium chloride and fresh water were mixed first with magnetic stirrer for 2 minutes.
3. Barite was added slowly and mixed for another 10 minutes.
4. Caustic soda is added slowly and mixed for another 2 minutes.
5. Calcium carbonate was added slowly and mixed for another 30 minutes.

3.2.2 Mud Balance

It is the equipment that already used to test the density of each of the mud samples. The procedures to test the density of the mud samples are:

1. The mud weight test will be using typical mud balance.
2. The lid from the cup is removed and completely fills the cup with the mud to be tested.
3. The lid is replaced and rotated until firmly seated, make sure some mud is expelled through the hole in the cup.
4. The mud is washed or wiped from outside the cup.
5. The balance arm is placed on the base, with knife edge resting on the fulcrum.
6. The rider is moved until the graduated arm is level, as indicated by the level vial on the beam.
7. At the left hand edge of the rider, the density is read on either side of the lever in all desired units without disturbing the rider.

Figure 3.3: Mud Balance

3.2.3 FANN Viscometer

The FANN viscometer is used to determine the viscosity and the GEL strength. The procedures to determine the apparent viscosity are:

1. Viscosity will be measured using FANN Viscometer.
2. A recently agitated sample in the cup is placed, tilted back the upper housing of the viscometer, located the cup under the sleeve and lowers the upper housing to its normal position.
3. The knurled knob is turned between the rear support posts to raise or lower the rotor sleeve until it is immersed in the sample to the scribed line.
4. Stir the sample for about 5 seconds at 600 rpm, and then select the RPM desired for the best.
5. Wait for the dial reading to stabilize.
6. Record the dial reading and RPM.

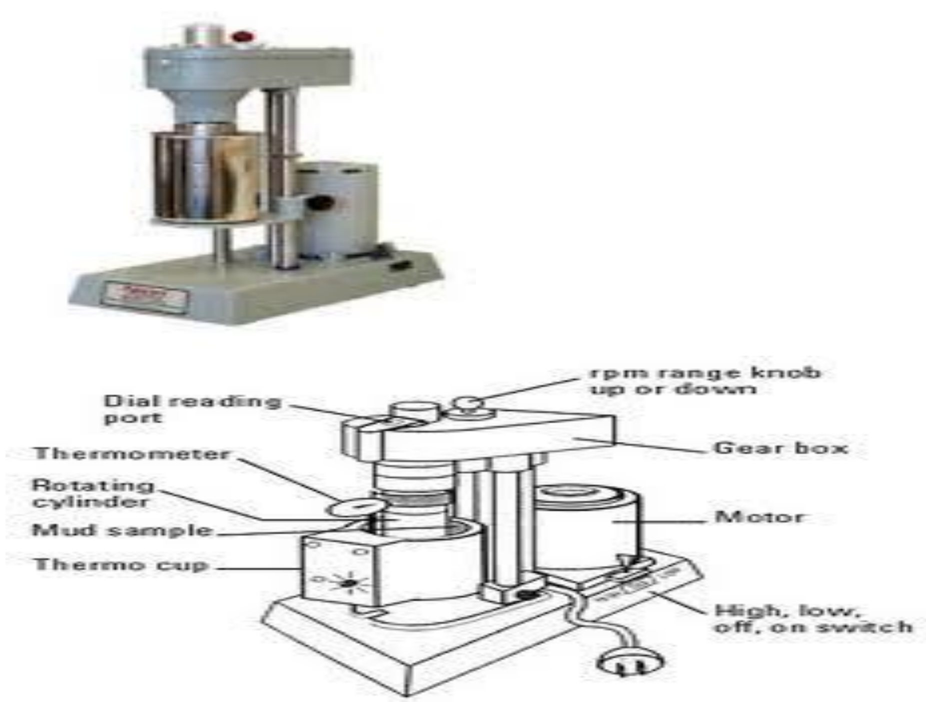


Figure 3.4: FANN Viscometer

The FANN viscometer is also used to determine the GEL strength as follows:

1. Place the fluid sample in position as in the procedure for plastic viscosity and yield point measurement.
2. Stir at high speed for 10 seconds.
3. Allow the fluid to stand undisturbed for 10 seconds. Slowly and steadily turn the hand wheel in the direction to produce a positive dial reading. The maximum reading is the initial gel strength in lb_f /100 ft^2. For instruments having a 3 rpm speed, the maximum reading attained after starting rotation at 3 rpm is the initial gel strength. Report the temperature of the sample in degrees F (°C).
4. Stir the fluid sample at high speed for 10 seconds and then allow the fluid to stand undisturbed for 10 minutes. Report the measurement as in Step 3 above and report the maximum reading as the 10-minute gel in lb_f /100 ft^2.

3.2.4 API Filtration Test (Low Pressure Low Temperature)

Measuring filtration behavior and wall-cake building characteristics of a mud is essential to drilling fluid control and treatment. The characteristics of filtrate, such as oil, water, or emulsion content are also important. The types and quantities of solids in the fluid and their physical and chemical interactions affect these characteristics. Temperature and pressure affect the physical and chemical interactions. Performing tests at low pressure/low temperature is necessary to determine the ability of the drilling fluid system to keep the wellbore stable.

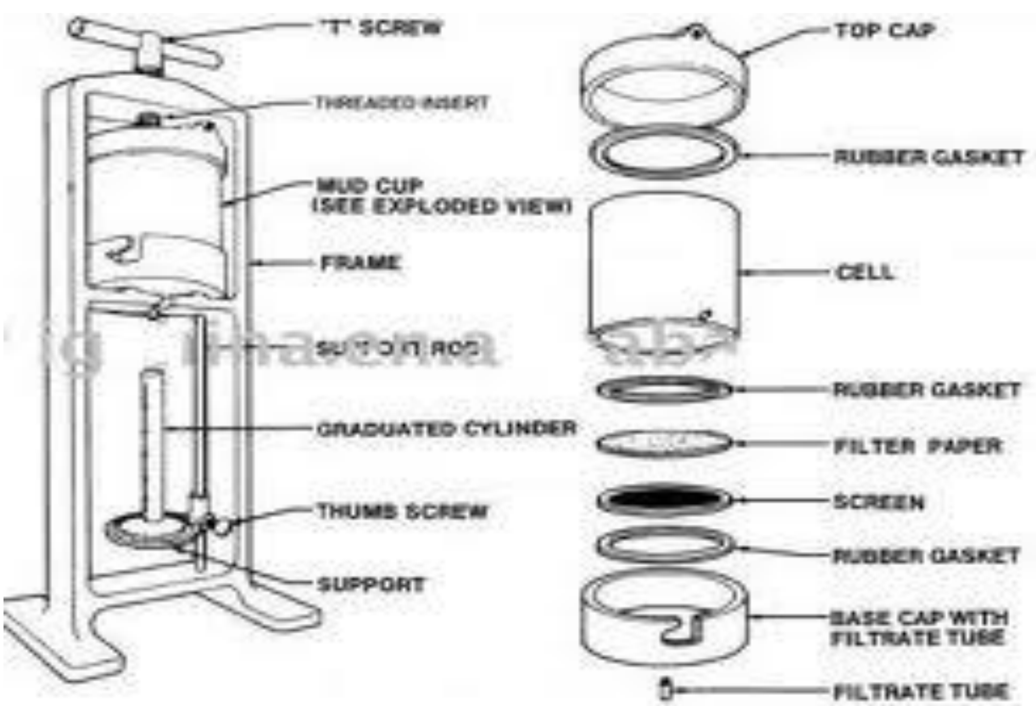


Figure 3.5: API Filter Test (LPLT)

As shown below, these are the procedures of conducting the filtration test (LPLT)

1. Be sure each part of the cell is clean and dry, and that the gaskets are not distorted or worn. Pour the sample of fluid into the cell and complete the assembly with the filter paper in place.
2. Place a dry graduated cylinder under the drain tube to receive the filtrate. Close the relief valve and adjust the regulator so a pressure of 100 ± 1.0 psi (690 ± 6.9 kPa) is applied in 30 seconds or less. The test period begins at the time of pressure application.
3. At the end of 5 minutes, measure the volume of filtrate. Shut off the flow through the pressure regulator and open the relief valve carefully. The time interval, if other than 5 minutes, shall be reported.
4. Volume of filtrate should be reported in cubic centimeters (to 0.1 cm^3) as the API filtrate. Report at the start of the test the fluid temperature in degrees F (°C). Save the filtrate for appropriate chemical testing.
5. Disassemble the cell, discard the fluid, and use extreme care to save the filter paper with a minimum of disturbance to the cake. Wash the filter cake on the paper with a gentle stream of water, or with diesel oil in the case of oil fluids. Measure the thickness of the filter cake, and report the thickness in 32nds of an inch or in millimeters.
6. Although standard descriptions are virtually impossible, such notations as hard, soft, tough, rubbery, firm, etc. may convey some idea of cake consistency.

3.3 Research plan

3.3.1 Gantt Chart

Table 3.2: Gantt chart for FYP II

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Booking the Mud Lab	x													
2	Mud Samples Preparations		x	x											
3	Mud Samples Tests				x										
4	Filtration Tests					x	x								
5	Submission of Progress Report							x							
6	Rheology Tests after Oven								x						
7	Filtration tests after Oven									x					
8	Results and discussions										x	x			
9	Pre-SEDEX												x		
10	Submission of Final Draft Report													x	
11	Submission of Technical Paper													x	
12	Oral Presentation														x
13	Submission of Dissertation														x

3.3.2 Project Deliverables

Table 3.3: Project deliverables for research

Event or Deliverable	Target Date	Responsibility
Project charter/draft preparation	Week 1-2	Discuss the suitability and feasibility of the project title
Project plan completed	Week 3-7	Draft the project planning and project activities
Project plan approved	Week 8-9	Proposal defence presentation to the UTP supervisor and panel examiners
Project execution initiated	Week 10	Conduct all the project activities as planned in the project charter
Project execution completed	Week 26	Complete the final documentation and ready for project deliverable
Project results presentation	Week 27-28	Oral presentation and simulation of the project title and evaluation from UTP and panel examiners (Pre-SEDEX)
Project completion	Week 28	Hand in the final documentation for further reference to UTP and panel examiners

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Results

There are five (5) samples of Water-Base Mud drilling fluid that have already been prepared in the lab using the weights mentioned before in (table 3.1). All these mud samples have been tested for their rheology and filtration properties, before making another five (5) samples with the same weights of the same ingredients, as made before, and put them in the Oven with 100 Cº temperature for 24 hours, and conduct the same tests again on them after this change in the temperature. Finally observation has been made on the results of the laboratory experimental tests on the five (5) mud samples with five (5) different weights of caustic soda before and after putting in the oven to increase the temperature.

4.1.1 Mud Rheology

Calculation for mud weight, plastic viscosity, apparent viscosity, and yield point:

Mud Weight (psi/100ft) = Mud Weight (ppg) X 5.195

Gel strength (dynes/cm^2) = Gel strength (lb/100ft^2) × 5.077

Plastic viscosity = μ_p = 600 RPM reading – 300 RPM reading

Apparent viscosity = μ_a = 600RPM reading ÷ 2

Yield Point = 300 RPM reading – Plastic viscosity

4.1.1.1 before the change in the Temperature

Table 4.1: WBM Rheology data before increasing the temperature

Sample	#1	#2	#3	#4	#5
Mud weight (ppg)	10.15	10.35	10.4	10.65	10.8
Mud weight (psi/100ft)	52.729	53.788	54.028	55.327	56.106
600 RPM reading	10	10	11	11	11
300 RPM reading	4	4	5	5	5
Plastic viscosity (cp)	6	6	6	6	6
Apparent viscosity (cp)	5	5	5.5	5.5	5.5
Yield point (Ib/100ft^2)	1	1	2	2	2
Gel Strenght, 10 sec. (Ib/100ft^2)	2	2	2	3	3
Gel Strenght, 10min. (Ib/100ft^2)	2.5	2.5	3	4	4

4.1.1.2 after the change in Temperature

Table 4.2: WBM Rheology data before increasing the temperature to 100Cº

Sample	#1	#2	#3	#4	#5
Mud weight (ppg)	9.6	9.8	9.9	10.1	10.4
Mud weight (psi/100ft)	49.872	50.911	51.431	52.469	54.028
600 RPM reading	4	4	4	5	5
300 RPM reading	2	2	3	3	3
Plastic viscosity (cp)	2	2	1	2	2
Apparent viscosity (cp)	2	2	2	2.5	2.5
Yield point (Ib/100ft^2)	0	0	2	1	1
Gel Strenght, 10 sec. (Ib/100ft^2)	1	1	1	1.5	2
Gel Strenght, 10min. (Ib/100ft^2)	1.5	1.5	2	2	2.5

4.1.2 API Filtration Test (LPLT)

The results of this test show the estimated time which is taken by each WBM mud sample during the filtration test to become a mud cake, and also enable us to determine the thickness of each mud cake.

4.1.2.1 Filtration Test before Increasing the Temperature

Table 4.3: Filtration test data before the oven

Sample	#1	#2	#3	#4	#5
100 (ml)	30 sec.	32 sec.	33 sec.	35 sec.	40 sec.
200 (ml)	60 sec.	60 sec.	65 sec.	70 sec.	75 sec.
250 (ml)	80 sec.	85 sec.	87 sec.	90 sec.	95 sec.
300 (ml)	100 sec.	105 sec.	110 sec.	113 sec.	120 sec.
320 (ml)	120 sec.	130 sec.	137 sec.	140 sec.	150 sec.

The five samples of the water-base mud have built up a mud cake with the same thickness which is (5mm) after the filtration test.

4.1.2.2 Filtration test after Increasing the Temperature

Table 4.4: Filtration test data after the oven

Sample	#1	#2	#3	#4	#5
100 (ml)	22 sec.	25 sec.	27 sec.	30 sec.	32 sec.
200 (ml)	45 sec.	47 sec.	50 sec.	55 sec.	60 sec.
250 (ml)	68 sec.	70 sec.	70 sec.	75 sec.	80 sec.
300 (ml)	85 sec.	88 sec.	90 sec.	93 sec.	98 sec.
320 (ml)	100 sec.	105 sec.	109 sec.	112 sec.	120 sec.

The five samples of the water-base mud after been heated in the oven have built up a mud cake with the same thickness which is (4.8mm) after the filtration test.

4.2 Discussions

4.2.1 Mud Preparation

First of all, the five Water-Base Mud (WBM) that have been prepared consist of different ingredients including the caustic soda which is the main concern of this study. Before going through the effect of changing the different weights of the caustic soda on the behavior of the five samples of the drilling mud, the function of each ingredient in each of the mud sample should be known to accurately determine the influence of using the different weights of the caustic soda on them. The table below shows the function of each of the ingredients.

Table 4.5: Function of mud ingredients in WBM

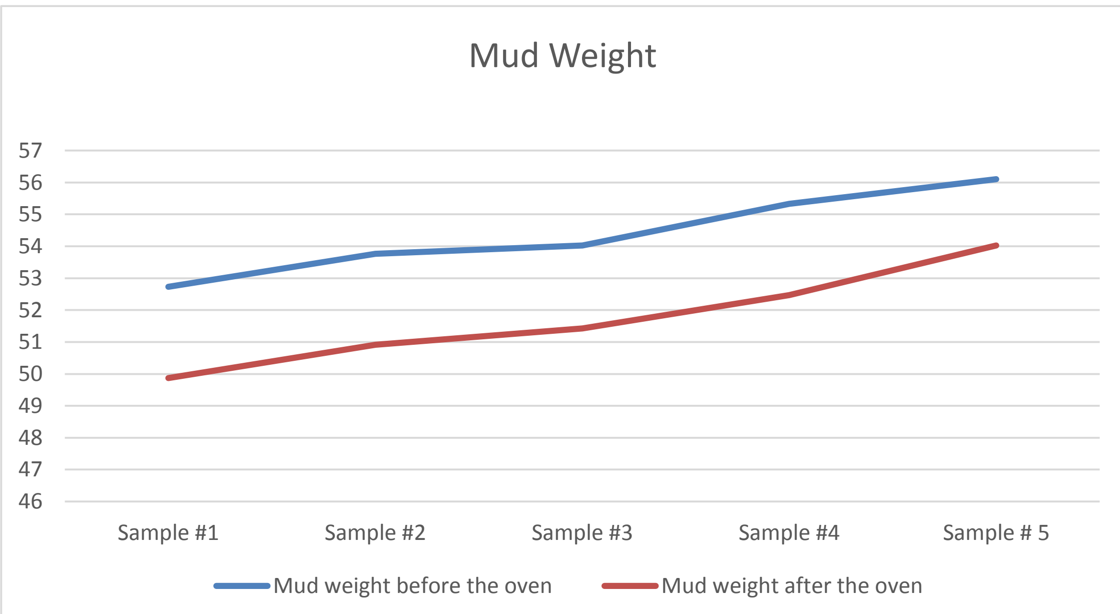
No	Item	Function
1	Fresh Water	It is used as base water
2	Soda Ash	It is a source of carbonate ions, which have a great effect in reducing the soluble calcium
3	Caustic Soda	It is used to increase the PH value of the composition, and also to maintain the alkalinity
4	Calcium Chloride	It is used for the drilling in the water-sensitive shale formations like the hard barite shale
5	Calcium Carbonate	It is used as a bridging agent to reduce clay swelling
6	Barite	It is used as a primary weight material to control the over balance formation pressure

As mentioned in the table above, the major purpose of using the caustic soda in the Water-Base Mud (WBM) is to increase the PH value in the drilling fluid system to keep the wellbore stable, and to maintain the alkalinity to support the equilibrium in the composition of the WBM down in the wellbore.

4.2.2 Mud weight

Starting from the first experimental test using the Mud Balance equipment in order to measure the density or the mud weight of each sample, it was found that when increasing the weight of the caustic soda in the compositions starting from sample #1 (0.2g) to sample #5 (1.0 g), the drilling mud density increases. In other words, the increase of the weight of the caustic soda in the drilling mud leads to increasing in the mud weight, as it increased from 10.15 ppg in the first sample to 10.8 in the fifth sample.

Figure 4.1: The mud weight (psi/100ft) before and after the oven



As shown in the graph, the mud weight also increases from sample #1, (0.2g) of caustic soda, after increasing the temperature to 100C° to sample #5, (1.0g) of caustic soda, from 9.6ppg to 10.4ppg. It means that the increase of the weight of the caustic soda in the WBM results in increasing of the composition weight, whatever any condition of the temperature. This could help more in supporting the subsurface pressure by the WBM hydrostatic pressure, keep the pressure balanced down hole is one of the major functions of the drilling fluids.

4.2.3 Mud Rheology

This part concentrates on the rheology properties of the Water-Base Mud (WBM). These properties include the plastic viscosity, apparent viscosity, yield point and the GEL strength. Starting with the plastic viscosity, as it has a great effect on how easy or hard for the drill bit to drill into the formation. The low plastic viscosity enables the bit to drill easier into the wellbore formation than the high plastic viscosity of the drilling fluid that is why low plastic viscosity is preferable for any drilling fluid to make it easy for the bit to drill more efficiently and faster. The apparent viscosity is just used when the fluid is measured at a given shear rate at a fixed temperature. The yield point is related more to the ability of the drilling fluid to remove the cuttings around the drilling bit in the wellbore and lift it to the annulus. The higher in yield point value, the more easier and efficient to transport and lift the cuttings around the drill bit to the annulus. On the other hand, for the GEL strength, it is preferable to be as low as possible because the higher value in the GEL strength, the harder for the bit to start drilling again after any stop of the drilling process for a period of time. While having tripping out, if the GEL strength value in the WBM is high, the drill bit will find it difficult to rotate after the trip. However, it will be easier for the drill bit to rotate again after the trip if the GEL strength value is low.

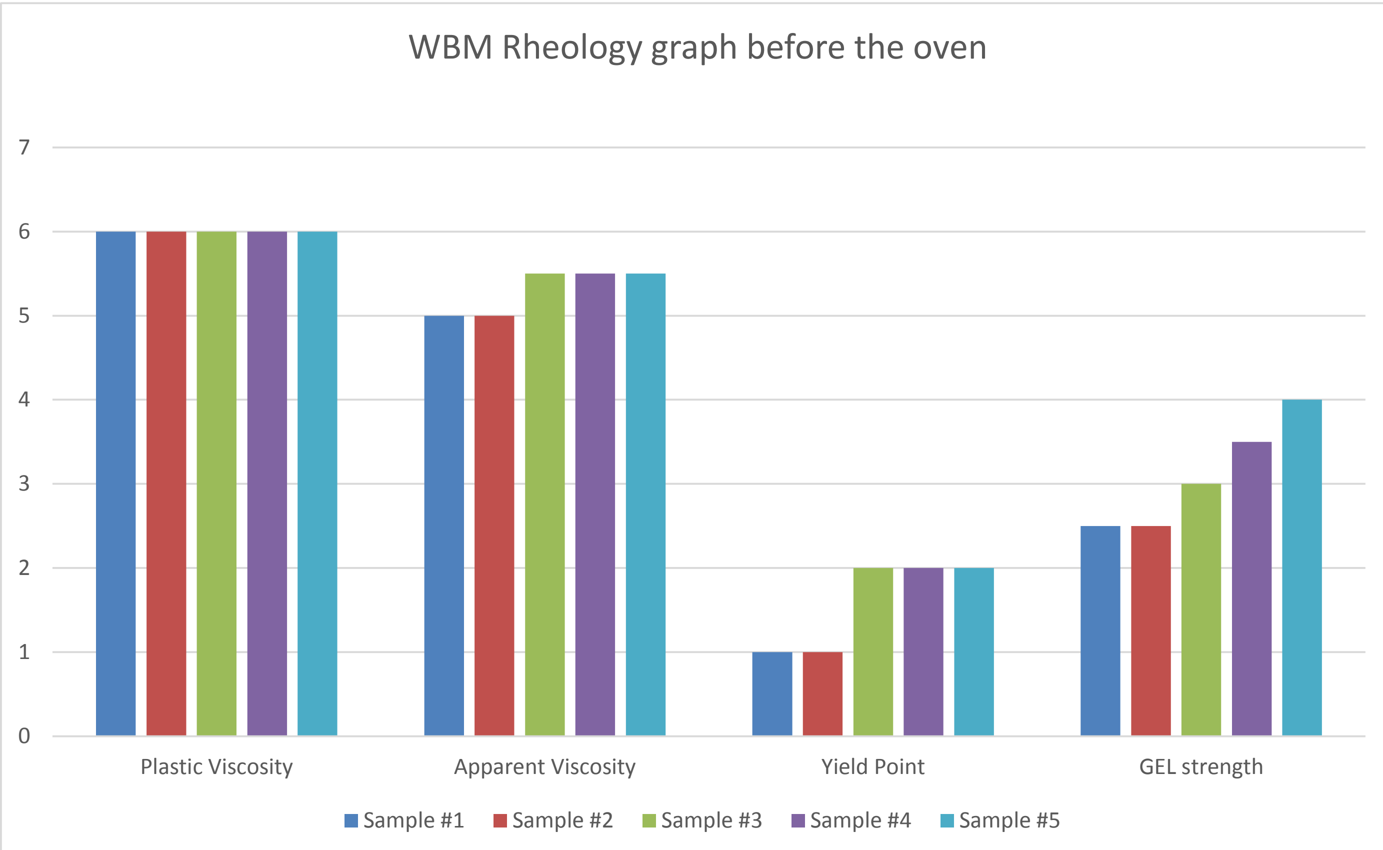
So, finally it can be concluded that low plastic viscosity, low apparent viscosity, high yield point and low GEL strength value are the major elements to make a good drilling fluid system.

From the results got from the FANN Viscometer tests, it was found out that while increasing the weight of the caustic soda in the WBM samples starting from sample #1 of (0.2g) to sample #5 of (1.0g) of the caustic soda, the plastic viscosity values are almost the same before and after increasing the temperature, but the apparent viscosity values have a slight increase from 5 (cp) to 5.5 (cp) before the change in the temperature, and from 2 (cp) to 2.5 (cp) using the oven to increase the temperature to 100C^o. It means that the increase in the weight of the caustic soda while making a Water-Base Mud drilling fluid may lead to a slight increase in the apparent viscosity value which is not preferable for a good drilling fluid as mentioned before.

For the yield point and GEL strength values, it was observed that the increase in the weight of the caustic soda from sample #1 (0.2g of caustic soda) to sample #5 (1.0g of caustic soda) results in increasing the yield point value for the samples before the oven from 1 Ib/ft^2 to 2 Ib/ft^{2}and from 0 Ib/ft^2 to 1 Ib/ft^2 after increasing the temperature for the all samples to 100C^o. it means that the increase of caustic soda in

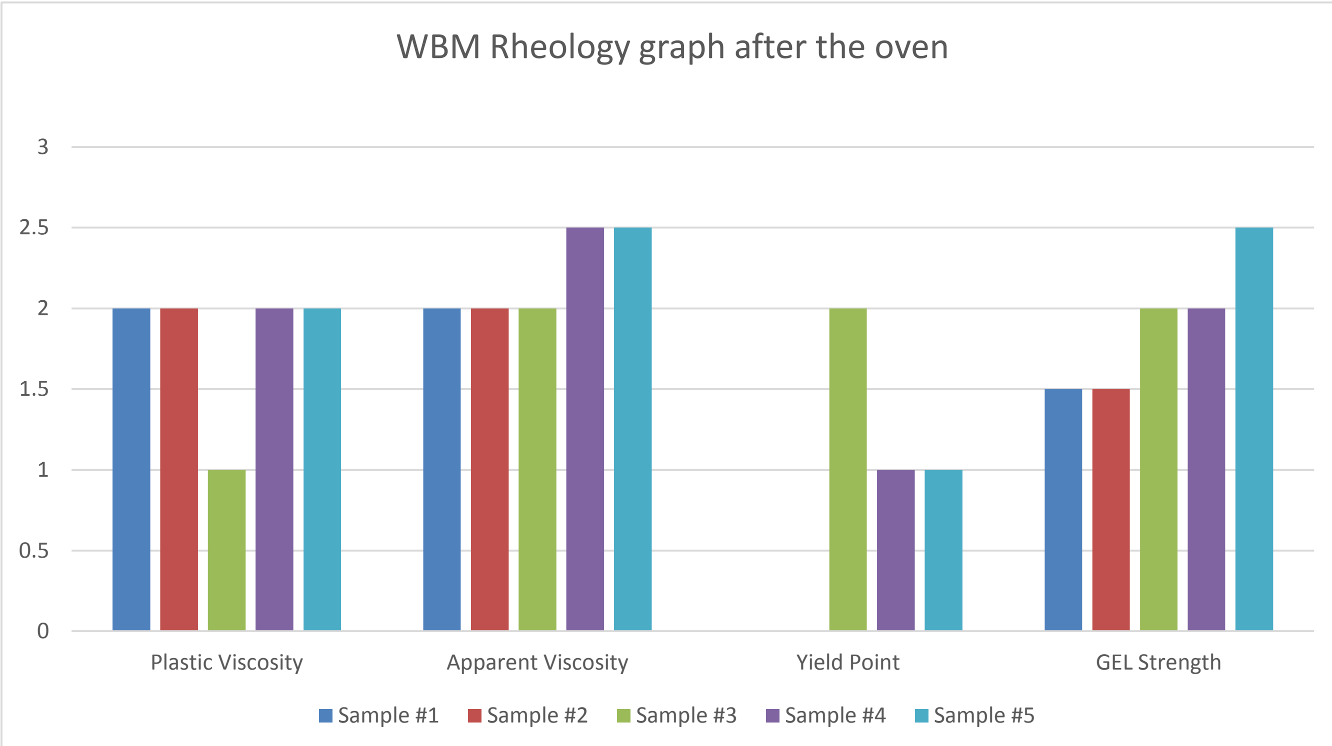
WBM fluids leads to increase in the yield point values at any conditions of the temperature which is preferable for a good WBM.

Figure 4.2: Mud Rheology graph before the oven



On the other hand, for the GEL strength values, while the increase in the weights of caustic soda from sample 1 to sample #5, the gel strength values increase from 2.5 Ib/ft² to 4 Ib/ft² before the change in the temperature. After the increase in the temperature to 100Cº, the GEL strength values also increase from 1.5 Ib/ft²in the first sample to 2.5 Ib/ft²in the fifth sample. It means that the increase in the weights of the caustic soda in the Water-Base Mud drilling fluids could lead to the increase of the GEL strength values of the compositions under any conditions of the temperature, which is not preferable as mentioned before.

Figure 4.3: Mud Rheology graph after the oven



Finally, it can be concluded that the increase of the ratio of the caustic soda in the Water-Base Mud drilling systems leads to a slight increase in the apparent viscosity while the plastic viscosity will be the same. It means that if there is a need to make the drilling operation faster or the wellbore formation is a little soft, the ratio of the caustic soda in the Water-Base Mud drilling fluid should be a little low.

For the yield point values, while increasing in the ratio of the caustic soda in the WBM drilling fluid, the yield point values increase. It means that when there is a problem in transporting the cuttings to the annulus, the ratio of the caustic soda in the WBM drilling fluid should be a little high to easily lift the cuttings.

For the GEL strength values, the increase of the caustic soda in the WBM results in a slight increase in the GEL strength. In other words, it means that when there is a need for the bit to rotate easily after ant tripping out, the WBM drilling fluid should have a low ratio of the caustic soda in order to have a low GEL strength values which make the drill bit rotate easily.

4.2.4 Filtration test (LPLT)

The last step of investigating the influence of the usage of different ratios of caustic soda in different five (5) samples of Water-Base Mud drilling fluid is to conduct the filtration test by using the API filter press under low temperature and low pressure. The main purpose of this test is to investigate the filtration behavior and wall-cake building characteristics of a mud, which is essential to drilling fluid control and treatment. The types and quantities of solids in the fluid and their physical and chemical interactions affect these characteristics. The filtration of mud causes the buildup of filter cake. Loss of fluid (usually water and soluble chemicals) from the mud to the formation occurs when the permeability is such that it allows fluid to pass through the pore spaces. As fluid is lost, a buildup of mud solids occurs on the face of the wellbore. This is the filter cake.

Mud measurements are confined to the static filtration. Filtration characteristics of a mud are determined by means of a filter press. The test consists of monitoring the rate at which fluid is forced from a filter press under specific conditions of time, temperature and pressure, then measuring the thickness of the residue deposited upon the filter paper.

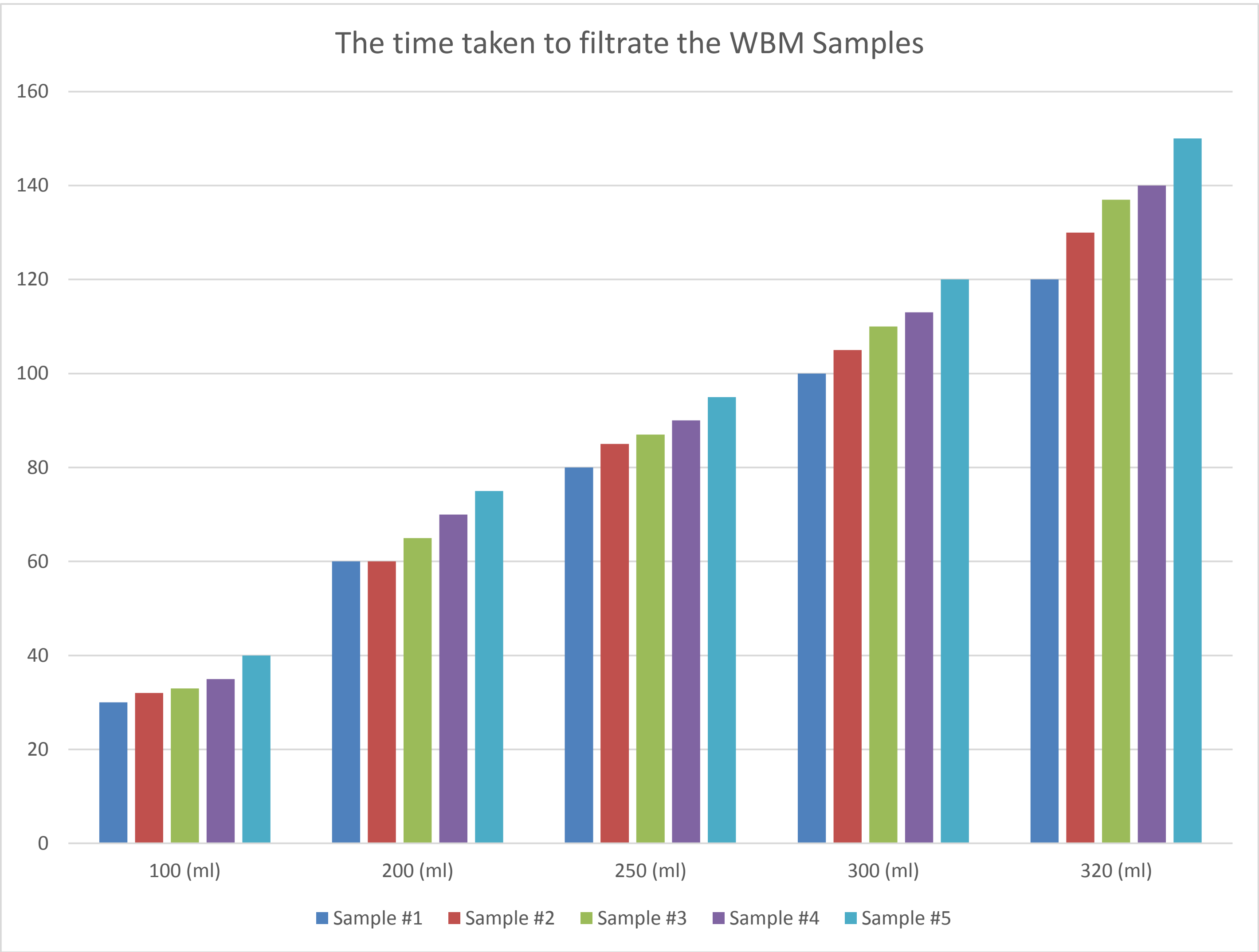
Excessive filtration and thick filter cake build up are likely to cause the following problems:

1. Tight hole, causing excessive drag.
2. Increased pressure surges, due to reduced down hole diameter.
3. Differential sticking, due to an increased pipe contact in filter cake.
4. Excessive formation damage and evaluation problems with wire line logs.

Most of these problems are caused by the filter cake and not the amount of filtration because the aim is to deposit a thin, impermeable filter cake. A low water loss may not do this, as the cake is also dependent upon solids size and distribution. It means that a good drilling must possesses a little thick filter cake built up after the filtration process a shorter period of time.

From the results got, it can be concluded that the increase of the ratio of the caustic soda in the Water-Base Mud drilling fluid samples leads to increase the time taken for each sample to build up the filter cake before and after using the oven to increase the temperature. As the time taken for the first sample (0.2 gram of caustic soda) to build up the mud cake wall is 2 min. Before using the oven and 100 sec. after using the oven, but in the fifth sample when increasing the ratio of the caustic soda (1.0g), the time taken was increased to 2.5 min. before using the oven and just 2 min. after the usage of the oven.

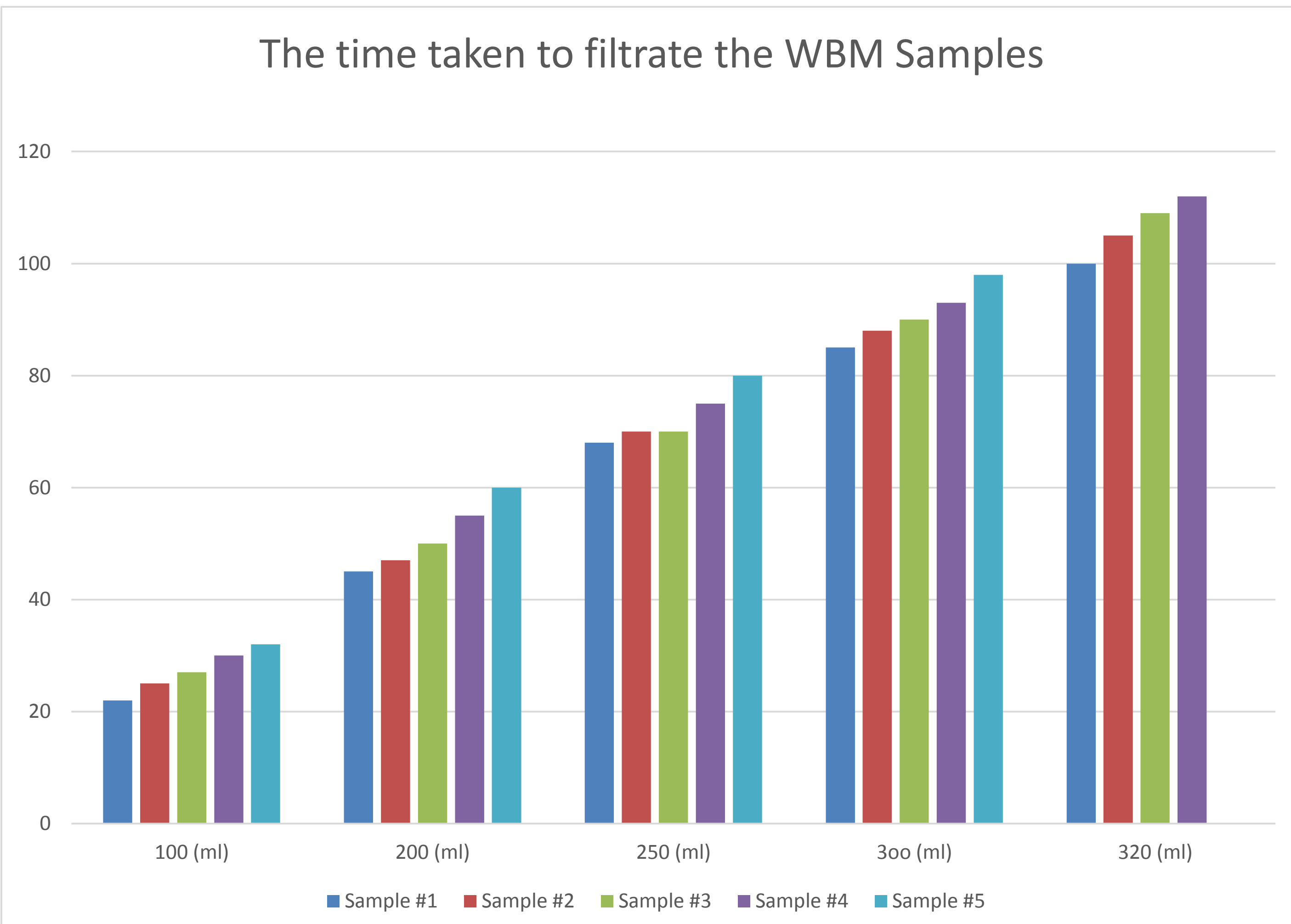
Figure 4.4: the filtration test graph before the oven



In other words, the usage of small weight of caustic soda in the WBM drilling fluid is better to make a good drilling fluid system if there is a problem like a tight hole in the wellbore under any conditions of the temperature.

From the results, it was observed that under high temperature of 100Cº, the thickness of the mud cake which was built up due to the filtration process (LPLT) is (4.8mm) which is better compared to the one formed without the usage of the oven which is (5mm).

Figure 4.5: the filtration test graph after the oven



CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Finally, the objectives of this research are already achieved. Different samples of Water-Base Mud compositions have been prepared with different weights of caustic soda. The Rheology tests and the API Filtration tests (LPLT) with and without increasing the temperature of the samples have been studied and done successfully. From these tests, various results and many conclusions have been got in order to investigate the effect of using different weights of the caustic soda in different samples of WBM compositions on the mud Rheology properties and the filtration properties of the drilling mud that help in more controlling the formation pressure and keep the stability.

From these results, it can be concluded that the increase of the weight of the caustic soda used in preparing the Water-Base Mud drilling fluid leads to:

- The increase in the WBM density or the mud weight, under any conditions of temperature, which is preferable when needed to balance the formation pressure down hole to keep the wellbore stable.
- A slight increase in the apparent viscosity of the mud samples. It means that, to make the bit drill faster and easier into the formation, the ratio of the caustic soda in the WBM composition should be low in order to decrease the viscosity of the drilling mud.
- The increase in the yield points values in the mud samples which is preferable so that the drilling fluid could easily lift the cuttings from around the drill bit to the annulus.
- A significant increase in the GEL strength values in the drilling fluid compositions. It means that after the tripping out, the ratio of the caustic soda in the WBM drilling fluid should be low to have a low values of GEL strength, so that the drill bit could easily rotate after the stop of the drilling operation.
- The increase in the time taken for the WBM samples to build up the filter cake wall, under any conditions of the temperature, which is not preferable.

5.2 Recommendations

- The ratio of the caustic soda should be increased in the Water-Base Mud drilling fluid if the formation pressure is high in order to balance the overbalanced pressure down hole by the hydrostatic pressure of the drilling mud to keep the stability of the wellbore.
- The ratio of the caustic soda should be decreased in the Water-Base Mud drilling fluid by the drilling mud engineer if the drilling operations are into soft formations, and there is a need to make the drilling operations easier and faster.
- The ratio of the caustic soda should be increased in the drilling fluid system, if there are hard formations during the drilling operations by the drilling mud engineer, so that the cutting could be easily lifted into the annulus.
- After the trip, the drilling mud engineer should decrease the ratio of the caustic soda in the WBM drilling fluid, so that the drill bit could easily rotate after the tripping out due to the low values of the GEL Strength in the drilling fluid compositions.
- The higher temperature in the wellbore could lead to a thinner mud cake wall which is better for its permeability.
- The ratio of the caustic soda in the WBM drilling fluid should be decreased by the drilling mud engineer, if the wellbore down hole is tight to protect the wellbore any excessive drags.

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