The New Biodegradable Surfactant Drilling Fluid for Offshore Drilling Environment

by

Mohd Majdan Bin Mohd Zarawi

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Petroleum Engineering)

JAN 2012

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Sonny Irawan)

Date: 16 April 2012

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JAN 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I, Mohd Majdan Bin Mohd Zarawi (I/C No: 890208-03-5665), am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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CHAPTER 1-INTRODUCTION

1.1 BACKGROUND OF STUDY

In oil and gas industry, there are many challenges faced before reservoir fluid produced out of reservoir rock. In drilling progress, the reservoir rock may be invaded by drilling fluid and cause several damage to the wall formation. This is called as formation damaged. Formation damage is defined as any type of a process which results in a reduction of the flow capacity of an oil, water or gas bearing formation [1].

In oil and gas reservoirs, formation damage has known as a source of serious productivity reductions as it could lead to water injectivity problems in many waterflood projects. The injectivity problem has reduces the effectiveness of recovery mechanism, mainly on third recovery mechanism. Besides, formation damaged has negative affect to oil and gas production as it could reduces the production due to its mechanism.

1.2 PROBLEM STATEMENTS

1.2.1 Problem Identification

In this study, the factors that reduce the effectiveness oil and gas (formation fluid) method will be realized. In oil and gas industry, the production of formation fluid out of production well drives by first recovery mechanism such as formation pressure. In Secondary Recovery, the reservoir is subjected to water flooding or gas injection to maintain a pressure that continues to move the oil from the reservoir up to the surface. After the productions through second recovery method become uneconomical, the formation production will be recovered through third recovery methods.

Third recovery method consists of 2 main group, thermal and non-thermal [2]. Thermal method consists of hot water, steam, electrical heating and in-situ while non- thermal method consists of miscible, chemical and gas drive. Chemical methods utilize a chemical formulation as the displacing fluid, which promotes a decrease in mobility ratio and/or an increase in the capillary number [3].

However, the usage of surfactant in chemical EOR creates an incompatibility condition between the additives used in drilling fluid. The effect of incompatibility is the reduction of reservoir permeability in the area between injection and production well. As the permeability reduces, the flow of injection fluid (for CEOR) becomes lower, resulting in decreasing of the CEOR efficiency. The less efficiency of CEOR would give negative impact to the production cost.

At the high temperature and high pressure, the properties of drilling fluid might be changed and will reduce their performance. For example, fluid loss of polymers increase as the temperature increase and this could cause serious damage to formation.

1.3 OBJECTIVES

- To determine the affect of surfactant in drilling fluid on permeability and filtrate loss at various temperature.
- To analyze the effects best amount of surfactant added into drilling fluid to get the best stability at various temperatures.

1.4 SCOPE OF STUDY

The scope of study for this project revolves around surfactant and its effects on the drilling fluid. The first stage of study consists of researching for industry case studies to understand the theory behind surfactant and drilling fluid. Other than that, understanding on the origin and effects of different molecular weight of surfactant is essential before moving to the second stage of study.

Based on the study, a compatible surfactant has been chosen for this project and will be tested in next stages. In the second stage, the experiments will be carried out standard American Petroleum Institute (API) to test the effect of the surfactant (PEG550) on water based drilling fluid (WBM). The most compatible mixture of surfactant and drilling fluid is known as sample solutions. Further evaluation has to be done by analyzing physical properties of the sample solution. The properties test may include density. Then, by using specific instruments and softwares, effects of surfactant against drilling fluid will be evaluated based on the rheology properties. The parameters of the properties:

- Fluid Loss (FL)
- Yield Point (YP)
- Plastics viscosity (PV)

The filtrate loss experiment also has been carried out to evaluate the amount of fluid loss into the reservoir when it is applied during the drilling operation. The less amount of fluid loss into the reservoir, the greater drill fluid will be to the well. The test also has been carried out at different temperature to evaluate the drilling fluid performance at higher temperature.

Finally, analysis and comparisons will be done base on the data gathered and research studies before. The analysis and comparisons will test the sample solution at various temperatures. The properties of the sample solution at the end of the test will be compared to their initial properties. From the test, the satiability of the sample solution at those temperatures will be identified.

1.5 FEASIBILITY OF THE PROJECT

This project is fully lab experimental based. In the time given, the project could be completed. This project can be completed within seven months given that everything will goes fine during that period. The objective can be achieved if the procedures are closely followed.

CHAPTER 2-LITERATURE REVIEW

2.1 FORMATION DAMAGED

Formation damage has known as a source of serious productivity reductions as it could lead to water injectivity problems in many waterflood projects. The injectivity problem has reduces the effectiveness of recovery mechanism, mainly on third recovery mechanism. Besides, formation damaged has negative affect to oil and gas production as it could reduces the production due to its mechanism.

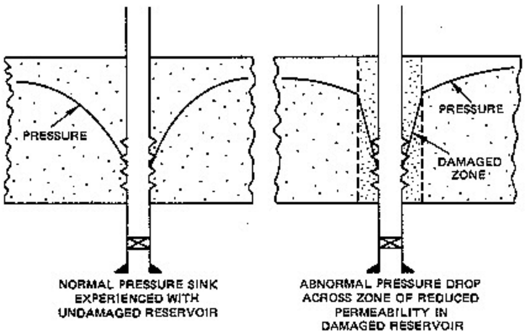


Figure 1: Formation Damage

Formation damage consists of many types of mechanism and they are mainly divided into 4 main groups which are Mechanically Induced Formation Damage, Chemically Induced Formation Damage, Biological Induced Formation Damage and Thermally Induced Formation Damage [4]. Mechanical mechanism formed due to fines migration, solids entrainment, and relative permeability (trapping) effects while chemical mechanism consist of Clay swelling, Clay deflocculation, Wax deposition, Solids precipitation, Incompatible precipitates and scales, Acid sludges, Stable emulsions, Chemical adsorption, and Wettability alteration. The last one is using biological concept by using bacteria and nutrients stream into a reservoir to solve problems such as plugging, corrosion, and toxidity.

2.2 DRILLING FLUID

Drilling fluid is a mixture solution of basic components such as solid, water and additive. They have ability to increase density (weight) of mud, balancing formation pressure and preventing a blowout. Another name for the solid material is Weighting Materials. In drilling fluid, water and oil are used for solvent in water based drilling mud and oil based drilling mud respectively.

Due to different condition and properties of well, the drilling fluid has to be designed to increase their compatibility for any different well by adding any additive. Currently, there are many kinds of additive has been use to improve the compatibility and performance of the drilling fluids. Each additive has different role in drilling fluid. The additives and their function are represents in the following table;

Functional Category	Function	Typical Chemicals
Weighting Materials	Increase density (weight) of mud, balancing formation pressure, preventing a blowout	Barite, hematite, calcite, ilmenite
Viscosifiers	Increase viscosity of mud to suspend cuttings and weighting agent in mud	Bentonite or attapulgite clay, carboxymethyl cellulose, & other polymers
Thinners, dispersants, & temperature stability agents	Deflocculate clays to optimize viscosity and gel strength of mud	Tannins, polyphosphates, lignite, ligrosulfonates
Flocculants	Increase viscosity and gel strength of clays or clarify or de-water low-solids muds	Inorganic salts, hydrated lime, gypsum, sodium carbonate and bicarbonate, sodium tetraphosphate, acrylamide-based polymers
Filtrate reducers	Decrease fluid loss to the formation through the filter cake on the wellbore wall	Bentonite clay, lignite, Na-carboxymethyl cellulose, polyacrylate, pregelatinized starch
Alkalinity, pH control additives	Optimize pH and alkalinity of mud, controlling mud properties	Lime (CaO), caustic soda (NaOH), soda ash (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), & other acids and bases

Lost circulation materials	Plug leaks in the welbore wall, preventing loss of whole drilling mud to the formation	Nut shells, natural fibrous materials, inorganic solids, and other inert insoluble solids
Lubricants	Reduce torque and drag on the drill string	Oils, synthetic liquids, graphite, surfactants, glycols, glycerin
Shale control materials	Control hydration of shales that causes swelling and dispersion of shale, collapsing the wellbore wall	Soluble calcium and potassium salts, other inorganic salts, and organics such as glycols
Emulsifiers & surfactants	Facilitate formation of stable dispersion of insoluble liquids in water phase of mud	Anionic, cationic, or nonionic detergents, soaps, organic acids, and water-based detergents
Bactericides	Prevent biodegradation of organic additives	Glutaraldehyde and other aldehydes
Defoamers	Reduce mud foaming	Alcohols, silicones, aluminum stearate ($C_{54}H_{105}AlO_6$), alkyl phosphates
Pipe-freeing agents	Prevent pipe from sticking to wellbore wall or free stuck pipe	Detergents, soaps, oils, surfactants

Table 1: Additives for Drilling Fluid

Basically, there are five basic properties are usually defined by the well program and monitored during drilling:

Rheology-A high viscosity fluid is desirable to bring cuttings to surface and suspend weighting agents in the drilling fluid. However, if the viscosity becomes too high, friction may impede the circulation of the mud causing extreme pump pressure, reduce drilling rate, and hamper the solids removal equipments. The flow regime is also affected by viscosity. On the rig, the measurements of viscosity performed using a Marsh funnel (an orifice viscometer) while plastic viscosity, yield point and gel strength can be measure using other viscometer such as Fann 35 viscometer [5].

Density- In order to prevent the borehole wall from caving in and to keep formation fluid from invading the well bore, sufficient hydrostatic pressure is required. The higher the density of the drilling fluid compared to the density of the cuttings, the easier it is to clean the hole. Besides, the cuttings will be less inclined to fall through the drilling fluid. But, if the drilling fluid weight is too high, rate of penetration decreases, this would increase chances of differential sticking and accidently fracturing the well increase. Thus, the drilling cost will increase. In general barite is used for weighting agent and mud balanced is used to measure the density of mud fluid [6]

Fluid loss- The application is to create a low-permeability filter cake to seal between the wellbore and the formation. Fluid loss can be controlled by restrict the invasion of the formation by filtrate and reduces the thickness of filter cake that builds up on the formation wall, reducing formation damage and the chances of differential sticking. On the rig, the static fluids loss is measure using a standard cell that forces drilling fluid through a screen, and also using a high temperature, high pressure test cell.

Solid contents- this material classified as high gravity (HGS)-barite and other weighting agents or low gravity agents-clays, polymers and bridging material [7]. The amounts and type of this material in drilling fluid could affect the drilling fluid properties. A high solid content, particularly LGS, will increase plastic viscosity and gel strength. High-solids drilling fluid have much thicker filter cakes and lower penetration rate. Large particles of sand in the drilling fluid cause abrasion on pump parts, tabular, measurement-while-drilling equipment and downhole motor. Measurement of total solids is traditionally performed using a retort.

Chemical properties- The chemical properties of drilling fluid are core of the performance and well stability. The properties must be predicted such as the dispersion of formation clays of other mud products.

2.2.1 Advantages and Disadvantages of Water Base Mud (WBM).

Advantages

i. Higher fracture pressure and fracture gradient than synthetic based mud (SBM).

ii. Low has solubility, promoting detection and handling of kicks.

iii. Also cheaper than SBM.

iv. Perceived to be more environmentally friendly than SBM.

v. Rheology/gels/density not as strongly affected by temperature and pressure (good stability).

Disadvantages

i. Has more accretion and bit-balling tendencies that could reduce rate of penetration (ROP).

ii. Less lubricating than SBM.

iii. More differential sticking potential (fluid loss control less tight)

iv. Hole cleaning in deviated well not as good as SBM.

2.2.2 Basic Mud Calculations

The following set of calculations describes how to either raise or lower the oil/water (O/W) ratio of an oil-based mud. If water enters an oil mud, the O/W ratio will decrease and if the O/W ratio is to be raised, then oil will have to be added. The amount of oil required to raise the O/W ratio can be calculated as follows:

Raise oil/water ratio - add oil

$$\frac{\%\ \text{oil} + x}{\%\ \text{water}} = \text{O/W (desired)}$$

If the O/W ratio is desired to be lowered, then water must be added based on the following equation:

Lower oil/water ratio - add water

$$\frac{\%\ \text{water} + x}{\%\ \text{oil}} = \text{O/W (desired)}$$

Example:

Retort analysis: 52% oil by vol
10% water by vol
How much oil is required to increase O/W to 88/12?
Therefore:

(52+X)/10 = 88/12
(52+X)/10 = 7.33
X = 21.3%
= 0.213 bbl oil/1 bbl mud

Resulting volume = 1 bbl mud + 0.213 bbl oil = 1.213 bbl

To convert to one barrel final volume, divide the mud and the oil volume by the resulting volume.

1 bbl mud /1.213 bbl = 0.82 bbl mud
0.213 bbl oil / 1.213 bbl = 0.18 bbl oil

2.3 SURFACTANT

Surfactant knows as “surface active agent” [2] as it has ability to spontaneously accumulate at the interface or surface between different fluids or between a fluid and solid due to their unique chemical properties. In surfactant, there are 2 parts of molecules. The first part is Iyophilic and it is attracted to one fluid or solid phase. The second part is Iyophobic and it repels the phase.

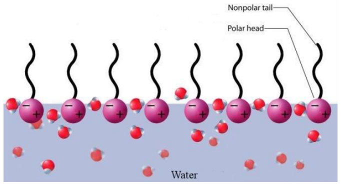


Figure 2: General Structure of Surfactant

The two different molecules would form 2 different hydrocarbon chains. The C_x-C_y hydrocarbon chain known as hydrophobic and it will repel water. Other chain is hydrophilic and it is water loving portions. This chain contains polar and ionic properties that would readily dissolve in water. The reduction of interfacial activity by any particular surfactant depends it concentration at the interface, which is the measurement of the surfactant effectiveness.

There are 4 types of surfactant that generally used in EOR. They are anionic, cationic, nonionic, and zwitterionic [2]. The classification of the surfactant depends on their nature of the hydrophilic group. For anionic, it carry negative charge and the cationic carry positive charge when they are in aqueous condition. The ions carried can be monovalent, divalent and also trivalent. Zwitterionics has ability to carry anionic or cationic characteristics and it depends on the environment such as pH of the solvent. The last is Non-ionic surfactants are brine tolerant, compatible with other classes of surfactant, hard water tolerant.

Non-anionic has much advantage in term of physical and chemical. The chemical structures of nonionic surfactants have many advantages over other types of surfactants. They are very useful in chemical blends and mixtures because of their electrical neutrality. This characteristic imparts a lower sensitivity to the presence of electrolytes in the chemical system. These surfactants offer a high degree of flexibility for synthesis to produce new non-ionic surfactant structure. One of them is Polyethylene Glycol (PEG) and has been selected to be used in this project due to their good features.

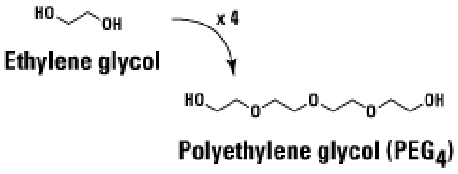


Figure 3: Polyethylene Glycol (PEG) molecule structure

2.4 POLYETHYLENE GLYCOL (PEG)

Polyethylene glycol (PEG) is a composition consists of polyether [8] and has many applications in current industrial from manufacturing to medicine. Other name for PEG is polyethylene oxide (PEO) or polyoxyethylene (POE). It might have other different name based on its molecular weight, and under the tradename Carbowax.

Polyethylene glycol is derived from ethylene glycol (or ethane-1,2-diol), which is the main ingredient in antifreeze agent. When ethylene glycol become polymerizes, it would reacts with itself in water, creating a variety of products containing varying numbers of ethylene glycol units. All these products are known as PEGs. Generally, the molecular formula for PEG is H(OCH2CH2)nOH, where n is the number of ethylene glycol units exist in the PEG polymer.

2.4.1 Types of PEGs

The molecular weights of PEGs represent the number of ethylene glycol units incorporated into each PEG polymer and vary from 300 grams per mole to 10,000,000 grams per mole. The molecular weight affects could the characteristics of each type or category of PEG. For example, low molecular weight PEGs might consist two-to-four ethylene glycol units per polymer and they are clear, watery liquids. Other PEGs that containing up to 700 ethylene glycol units per polymeric product has characteristic of clear and thick liquids. The higher molecular weight of PEGS could reach up to 1,000 or more ethylene glycol units per polymeric product and they are waxy solids.

2.4.2 PEG Physical Properties

Ethylene glycol has physical properties just like water as it is a clear, colorless, odorless, and liquid form [9]. It is also hygroscopic and completely miscible with many polar solvents such as water, alcohols, glycol ethers, and acetone. Its solubility is low however, in non-polar solvents, such as benzene, toluene, and chloroform. Ethylene glycol is very hard to be crystallized as it would forms a highly viscous, super-cooled mass that finally solidifies to produce a glasslike substance when cooled. It has been widely applied as the freezing point reducer as it mixed with water [10]. The following table shows the general physical properties of ethylene glycol;

Table 2: Physical Properties of Ethylene Glycol

Boiling point at 101.3 kPa	197.60 °C
Freezing point	-13.00 °C
Density at 20°C	1.1135 g/cm3
Refractive index, *nD*20	1.4318
Heat of vaporization at 101.3kPa	52.24 kJ/mol
Heat of combustion	19.07 MJ/kg
Critical temperature	372 °C
Critical pressure	6515.73 kPa
Critical volume	0.186 L/mol
Flash point	111 °C
Ignition temperature	410 °C
Lower explosive limit	3.20 vol%
Upper explosive limit	53 vol%
Viscosity at 20 °C	19.83 mPa.s
Cubic expansion coefficient at 20 °C	0.62·10-3 K-1

Source: *Ullmann's Encyclopedia of Industrial Chemistry- Ethylene Glycol*; Siegfried Rebsdat,Dieter Mayer-2000

2.4.3 PEG Chemical Properties

The ethylene glycols generally known as diols, and they are dihydirc alcohols that have an aliphatic carbon chain. The two hydroxyl groups provide high water solubility and hygroscopicity and reactive sites. PEG is perfectly soluble in water, but solubility decreases with molecular weight of polymer increasing.The increasing of glycols affects some of the properties of ethers due to the ether linkage in the molecular structure. Besides, the reactions of the ethylene glycols are similar to those of the monohydric alcohols in which the hydrogen group is replaced by halogens. The typical reactions that generally applied in industrial are as follows:

- Esters

The reaction between organic acids with ethylene glycol produces mono- and diesters [11]. The result obtained is dependent on the molar ratio of the acid to the glycol.

$(CH2OH)2 + RCOOH \rightarrow RCOOCH2\text{-}CH2OH + H2O$

$(CH2OH)2 + 2RCOOH \rightarrow RCOOCH2\text{-}CH2OOCR + H2O$

Polyesters produced form the reaction between ethylene glycol with polybasic acids or their derivatives such as Bishydroxyethyl terephthalate. It is used to produce polyethylene terephthalate, extract from the condensation processes of ethylene glycol with dimethyl terephthalate or terephthalic acid.

- Ethers

Ethylene glycol could exist in many forms such as mono- or diethers because of its two hydroxyl groups. The monoalkyl ether can be produced by the reaction between dialkyl sulfates with ethylene glycol. The reaction of ethylene glycol with ethylene oxide produces higher glycols or ether glycols [11].

- Oxidation Derivatives

The oxidation processes of ethylene glycol with nitric acid or in the vapro phase using oxygen cretes glyoxal [11].

$(CH2OH)2 + O2 \rightarrow (CHO)2 + 2H2O$

2.5 EFFECTS SURFACTANT

Formation damaged occurred due to several reason such as contact of completion fluids, workover fluids, or stimulation fluids with producing formation. The formation damage also increase by high density brine at high temperature inside the reservoir. Recently, formation damaged can be reducing using surfactant by preventing water block and emulsion.

The formation damaged is reducing by preventing water block using specific elements such as alkylpolyglycosides, ethoxylated alcohol and linear alcohol with the hydrocarbonaceous liquid. The elements form a mixture capable of forming a Winsor Type II or a Winsor Type III microemulsion with water positioned in the formation, thereby create a very low interfacial tension (IFT) microemulsion system [2]. The low IFT with the excess water phase allows the trapped water to be mobilized and displaced out of the formation. As a result, the permeability of the formation is maintained and reduces the effect of formation damage.

The surfactant also has ability to improve the stability of conventional rheology modifiers and fluid loss polymers in drilling fluids [12]. Non-ionic surfactant extracted from polyglycol has been identified could benefit HPHT stability far above their cloud point temperature (CPT) in solution. When react together with polymers crates polymer-polyglycol association and shields the polymer from oxidation (the polyglycol acts as a sacrificial agent), thereby reducing the degradation rate. As the degradation process of polymer is reduced, temporal stability of the drilling fluid can be maintained at high temperature.

Hydrophobically modified PEGs the adsorption behavior is quite different from that observed for homopolymers and is influenced by the balance of hydrophilic moieties (ethylene oxide units) and the lipophilic moieties (aliphatic groups). Both nunmodified and the hydrophobically modified PEG's, are able to readily penetrate the interlamellar spaces of smectite-rich clays. Besides, polymers are able to penetrate into the interlamellar spaces of the clay. However, in the presence of potassium ions the entrance was limited to only one layer of polymer. The longer the unmodified polymer chain length, the greater the water amount displaced in the adsorption process [13].

PEG chains have ability to adsorb on the interlayer spaces of the clay [14], while the alkyl segment is kept on the external surfaces. For example, hydrophobic modification of PEG400 with long alkyl chain (lauric acid) significantly changed the adsorption behavior of the polymer, enhancing its affinity for the clay surface. This adsorption model is particularly interesting for the PEG inhibition mechanism, since it predicts that the hydrophobic alkyl chains of modified PEGs could block the interlayers of the clay, hindering the water entrance thus, preventing swelling and disintegration of clay particles.

CHAPTER 3-METHODOLOGY

3.1 RESEARCH FLOW

Figure 6 below describes the overall methodology and general flow of this project.

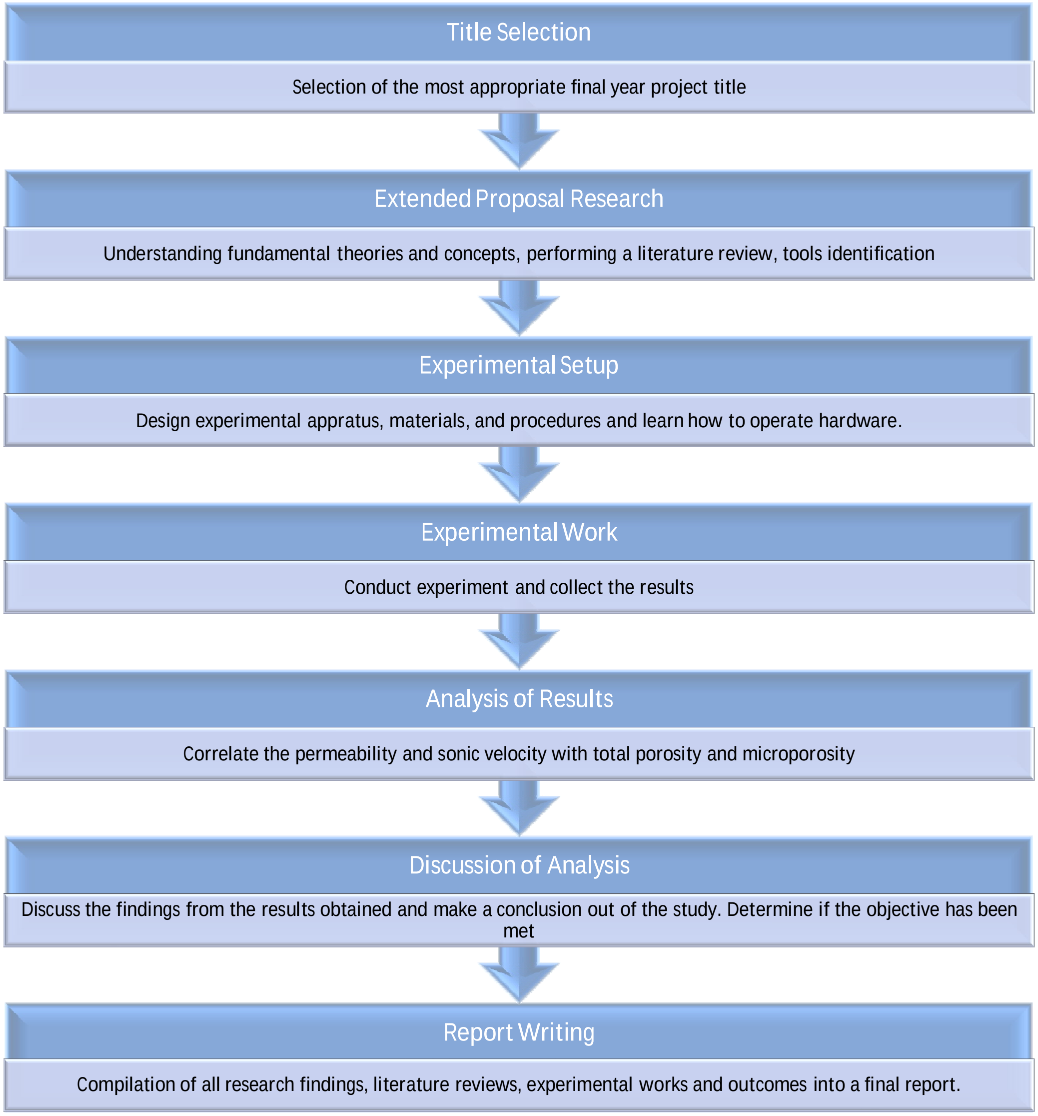


Figure 4: Flowchart representation of Project Methodology

3.2 PROJECT ACTIVITIES

Table 3: Project activities planned for Final Year Project

Activities/Progress	Starting Date	Finishing Date
Survey on the availability of suggested experiment apparatus and material.(obj.1 & 2)	1st November 2011	4th November 2011
Study on method to evaluate the physical properties and rheology of surfactant and drilling fluids. (obj.1 & 2)	5th November 2011	14th November 2011
Study on surfactant effects on drilling fluid. (obj.2)	15th November 2011	28th November 2011
Preparation of drilling fluids. (obj.1)	29th November 2011	11st December 2011
More study on surfactant, drilling fluid and their reaction mechanism. (obj.1 & 2)	12nd December 2011	31st December 2011
Experiment on sample solution to get physical properties data (obj.1)	1st January 2012	15th January 2012
Experiment on effects of surfactant on drilling fluid in term of rheology properties. (obj. 2)	16th January 2012	31st January 2012
Experiment on effects of surfactant on drilling fluid in term of stability at various temperatures. (obj. 2)	1st February 2012	25th February 2012
Analysis of the data	26th February 2012	13th March 2012
Report documentation	14th March 2012	30th April 2012

3.3 GANTT CHART & KEY MILESTONES

Table 4: Gantt chart and Key Milestone through the Final Year Project

	1^{ST} SEM				2^{ND} SEM			
Activity	S	O	N	D	J	F	M	A
Selection of Project Topic	🟥	🟥						
Preliminary Research Work		🟥						
Submission of Extended Proposal Defense			🟥					
Survey on the availability of suggested material and experiment apparatus			🟥					
Purchase unavailability things and material. Study on how to prepare the sample solutions.			🟥					
Defense proposal. Present details on methodology of the experiment.			🟥					
Drilling fluid preparation				🟥				
Submission of Interim Draft Report				🟥				
Submission of Interim Report				🟥				
Experiment on sample solution to get physical properties data					🟥			
Experiment on effects of surfactant on drilling fluid in term of rheology properties					🟥			
Experiment on effects of surfactant on drilling fluid in term of stability at various temperatures						🟥		
Analysis of the data						🟥	🟥	
Report documentation							🟥	🟥

3.4 MATERIALS AND EQUIPMENTS

3.4.1 Equipments

Figure 5: Mud Weight Balance

Figure 6: LTLP Filtrate Loss

Figure 7: Fann 35

3.4.2 Material

i. 9-alkoxy, 10-hydroxy-methyloctanoate – PEG550

ii. Base Fluid for experiment 1:
  - 0.3 ppb XC
  - 1 ppb PAC LV
  - 10 ppb KCl
  - 0.5 ppb PHPA
  - 0.2 ppb NaOH
  - 10 ppb $CaCO_3$

iii. Base Fluid for experiment 2:
  - 1 ppb XC
  - 4 ppb PAC-L
  - 10 ppb $CaCO_3$
  - 20 ppb OCMA clay
  - 80 ppb barite

iv. Base Fluid for experiment 3:
  - 1 ppb XC
  - 4 ppb PAC-L
  - 10 ppb $CaCO_3$
  - 20 ppb OCMA clay
  - 80 ppb barite

3.5 METHODOLOGY

3.5.1 PEG 550 Productions

Surfactant for this project has been tested in laboratory to be used in surfactant flooding in Malay Basin. Their properties will lead to the determination of the volume of surfactant needed for this experiment. The surfactant that will be used is PEG surfactant based derived from natural oil specifically it is a mix of 9-alkoxy, 10-hydroxy-methyloctanoate. The specific name for the surfactant is PEG550. Properties of the PEG;

- Non-ionic
- Water soluble
- Stable up to 60^0C (will form milky solution in high temperature)
- Compatible up to 35000ppm (in sea water)
- Density solution in 1% solution have density of 1
- Molecular Weight : 350/550/mixture
- Not flammable

Polyethylene glycol is produced by interaction of calculated amount of ethylene oxide with water, ethylene glycol or ethylene glycol oligomers. Then, acidic or basic catalysts are used to catalyze the reaction. During the reaction, Ethylene glycol and its oligomers are preferable as a starting material than water, because of it allows obtaining polymer with narrow molecular weight distribution. Polymer chain length depends on the ratio of reactants.

Alkali catalysts such as sodium hydroxide NaOH, potassium hydroxide KOH or sodium carbonate Na_2CO_3 are used to prepare low-molecular polyethylene glycol. Then, the low-molecular PEG structures are coupled to another larger molecule, such as castor oil to produce non-ionic detergents. This procedure is known as PEGylation.

3.5.2 Mud Preparation for Lab Test

The mud prepared using a formula designed from the papers study. For those experiments, the mud has prepared in 2 main different compositions. The first one is based fluid, which only consisted of distilled water, XC and PEG 550. They are produced in 175ml of distilled water for each different concentration of PEG 550. The solution created in 4 different concentrations of PEG 550 and represents in the table below:

Table 5: Based Fluid Formulation

	Based-no PEG	1st trial-1% of PEG	2nd trial-2% of PEG	3rd trial-3% of PEG
XC (g)	1	1	1	1
PEG 550 (ml)	0	1.75	3.5	5.25

The second group of mud contains other extra material or additive which has its specific role in the mud. They are XC, ALCB, CaCO3, OCMA clay, and Barite. The mud also prepared using 175ml for each different concentration of PEG550. The table below represents the volume of each additive used to prepare the mud:

Table 6: Based Mud Formulation

	Based Mud-no PEG	1st trial-1% of PEG	2nd trial-2% of PEG	3rd trial-3% of PEG
XC (g)	0.5	0.5	0.5	0.5
ALCB (g)	2	2	2	2
CaCO3 (g)	5	5	5	5
OCMA clay	10	10	10	10
Barite	40	40	40	40
PEG 550 (ml)	0	1.75	3.5	5.25

The mud need to be prepared using proper steps because different method of mud preparation would affect the properties. The mud of were prepared based on the following steps:

i. Place 175ml of distilled water into a multi-mixer cup.
ii. Put 0.5g of XC and stirred. The stop watch used to measure the mixing time for each steps.
iii. 5 minutes later, add 2g of ALCB and stirred for 2 minutes.
iv. Then, add 10g of barite and stirred until the stopwatch reach 10 minutes.
v. Place 10g of OCMA clay and stirred for next 25 minutes.
vi. At minutes of 35, put 5g of $CaCo_3$ and stirred for 5 minutes.
vii. Finally, place PEG550 with the amount based on the concentration required and stirred for next 5 minutes.

3.5.3 Lab Test Evaluation on the Mud

a) Investigate of drilling fluid properties.

In order to meet the objectives which are to determine the rheology of the surfactant drilling fluid and to evaluate the fluid loss properties of the mud, several experiments have to be conducted. Below is the flow of the experiments;

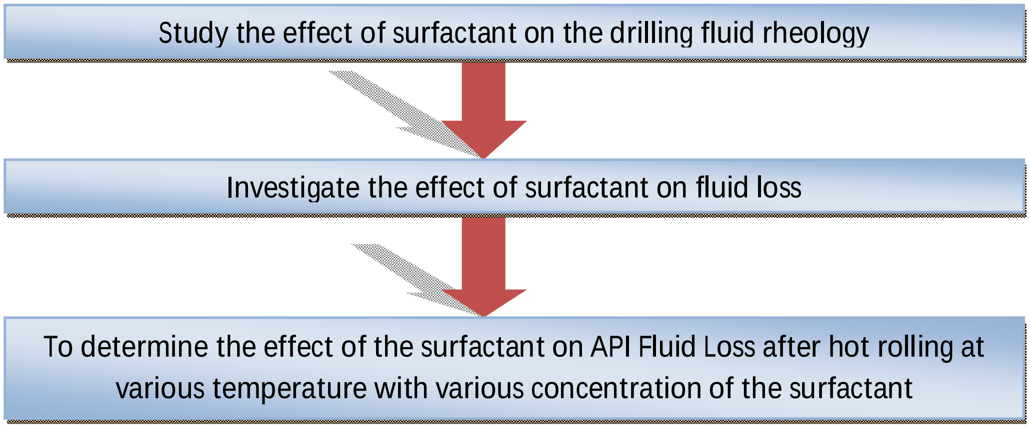


Figure 8: Experiment and Test Methodology

This experiment is to identify the density and viscosity of drilling fluid or mud. This experiment will be conducted at API standard condition with API standard procedure. The experiments would use simple equipments called Mud Weight Balance. The data from this experiment will be used for the next experiments. The test procedure will be conducted as follows;

Mud Density

Mud Density is used to control subsurface pressures and stabilize the wellbore. Mud density is commonly measured with a mud balance capable of ±0.1 lb/gal accuracy. A mud balance calibrated with fresh water at 70° ±5° should give a reading of 8.3 lb/gal.

Step:

1. Measure and record the temperature of the sample of mud to be tested.
2. Place the mud balance base on a flat, level surface.
3. Fill the clean, dry, mud balance cup with the sample of mud to be tested. Rotate cap until it is firmly seated. Ensure that some mud is expelled through the hole in the cap to remove any trapped air or gas.
4. Place thumb over hole in cap and hold the cap firmly on the cup. Wash or wipe the outside of the cup, and dry.
5. Place balance arm on the support base and balance it by moving the rider along the graduated scale until the level bubble is centered under the center line.
6. Read the density (weight) of the mud shown at the left-hand edge of the rider and report to nearest 0.1 lb/gal. Enter result on API Drilling Mud Report as Weight (lb/gal, lb/ft3) or Specific Gravity).

Marsh Funnel Viscosity

Marsh Funnel viscosity is used to indicate relative mud consistency or thickness. Marsh Funnel viscosity is the time required (seconds) for a quart of mud to flow through a 2-in. long, 3/16-in. diameter tube at the bottom of the Marsh Funnel. This viscosity measurement is used to periodically report mud consistency. One quart of water should flow through a Marsh Funnel in 26±0.5 seconds.

Step:

1. Hold one finger over the orifice at the tip of the funnel. Pour the mud sample through the funnel screen until mud reaches the bottom of the screen (1500 cm3). Place viscosity cup beneath funnel tip. Remove finger and start stop watch.
2. Stop the watch when the mud level reaches the 1-qt mark on the viscosity cup.
3. Record the number of seconds required to outflow 1-qt of mud. Enter on Drilling Mud Report as Funnel Viscosity (sec/qt) API.
4. Measure and record temperature of mud sample to ±1°F.

b) Study the effect of surfactant on the drilling fluid rheology.

The experiments are carried out to measure the rheology properties of the drilling fluid or sample solution before and after added with other additive (non-ionic surfactant). The parameter measured will be yield point (YP), gel strength and plastic viscosity (PV). The test procedure will be conducted as follows;

Rheology

Rheological properties measured with a rotational viscometer are commonly used to indicate solids buildups flocculation or deflocculation of solids, lifting and suspension capabilities, and to calculate hydraulics of a drilling fluid.

A rotational viscometer is used to measure shear rate/shear stress of a drilling fluid - from which the Bingham Plastic parameters, PV and YP, are calculated directly. Other rheological models can be applied using the same data. The instrument is also used to measure thixotropic properties, gel strengths. The following procedure applies to a Fann Model 35, 6-speed VG Meter.

Plastic Viscosity (PV) and Yield Point (YP)

Step:

1. Obtain a sample of the mud to be tested. Record place of sampling. Measurements should be made with minimum delay.
2. Fill thermal cup approximately 2/3 full with mud sample. Place thermal cup on viscometer stand. Raise cup and stand until rotary sleeve is immersed to scribe lie on sleeve. Lock into place by turning locking mechanism (Figure 6).

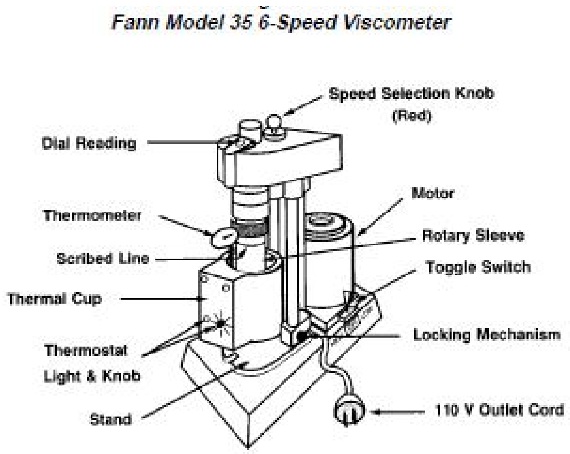


Figure 9: Fann Model 35 6-Speed Viscometer

3. Place thermometer in thermal cup containing sample. Heat or cool sample to desired test temperature of 115° ±2°F.
4. Flip VG meter toggle switch, located on right rear side of VG meter, to high position by pulling forward.
5. Position red knob on top of VG meter to the 600-rpm speed. When the red knob is in the bottom position and the toggle switch is in the forward (high) position -this is the 600-rpm speed (Figure 7).

(Caution: Change gears only when motor is running.)

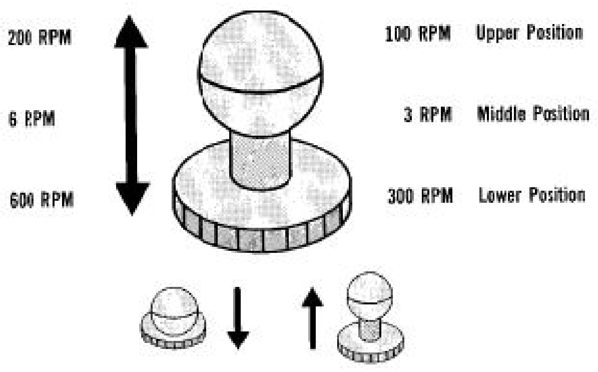


Figure 10: Speed Selection Knob

6. With the sleeve rotating at 600-rpm, wait for dial reading in the top window of VG meter to stabilize (minimum 10 seconds). Record 600-rpm dial reading.

7. With red knob in bottom position, flip the VG meter toggle switch to low position by pushing the toggle switch away from you. Wait for dial reading to stabilize (minimum 10 seconds). Records 300-rpm dial reading. [See Step 8 to calculate the Plastic Viscosity and Yield Point].
8. The Plastic Viscosity and Yield Point are calculated from the 600-rpm and 300-rpm dial readings as follows:

$$\text{PV,cP} = \left(\begin{matrix}\text{600-rpm}\\ \text{dial reading}\end{matrix}\right) - \left(\begin{matrix}\text{300-rpm}\\ \text{dial reading}\end{matrix}\right)$$

$$\text{YP,lb/100 ft}^2 = \left(\begin{matrix}\text{300-rpm}\\ \text{dial reading}\end{matrix}\right) - \left(\begin{matrix}\text{Plastic}\\ \text{Viscosity}\end{matrix}\right)$$

Gel Strength (10-sec/10-min)

Step:

1. With red knob in bottom position, flip toggle switch to 600-rpm position (forward position). Stir mud sample for 10 seconds.
2. Position red knob to the 3-rpm speed. When the red knob is in the middle position and the toggle switch is in low (rear) position - this is the 3-rpm speed. Flip toggle switch to off position. Allow mud to stand undisturbed for 10 seconds.
3. After 10 seconds, flip toggle switch to low (rear) position and note the maximum dial reading. This maximum dial deflection is the 10-second (initial) gel strength in lb/100 ft2. Record on the mud check sheet.
4. Pull toggle switch to high and position red knob to 600-rpm speed. Stir mud for 10 seconds.
5. After 10 seconds, and while mud is still stirring, position red knob to the 3-rpm speed. Flip toggle switch to off position and allow mud to stand undisturbed for 10 minutes.
6. After 10 minutes, flip toggle switch to low (rear) position and note the maximum dial reading. This maximum dial deflection is the 10-minute gel strength in lb/100 ft2. Record on the mud check sheet.

c) Investigate the effect of surfactant on fluid loss.

The experiments are carried out to measure the amount of fluid loss after flow through porous media. The large quantities of collected drilling fluid shows that the drilling fluid invasion is high, which mean high fluid loss. If the volume collected small, that indicate the fluid loss is low after flow through the porous media. Three different concentrations of sample solution will be tested in this experiment. The test will performed for 16 hours of hot rolling base solution of XC/PAC/KCl/PHPA mud with or without surfactant at 60^0C with various addition of surfactant. The test procedure will be conducted as follows;

Static Filtration Tests

Static filtration tests are used to indicate filter cake quality and filtrate volume loss for a drilling mud under specific testing conditions. Filtration characteristics are affected by the types and quantities of solids and their physical and chemical interactions. Temperature and pressure further affect these solids and their interactions. To operate any equipment, manufacturer's instructions should be carefully read. The following are general instructions for a possible configuration of Low-Pressure/Low-Temperature Filtration and High-Pressure/High-Temperature Filtration equipment. To operate any other units, manufacturer's instructions should be carefully read before attempting to perform testing.

Low-Temperature/Low-Pressure Filtration

Control of filtration properties of a drilling fluid can be useful in reducing tight hole conditions and fluid loss to formations.

1. Open main air valve by turning handle (located on lab bench) counter clockwise. Adjust regulator to read 100 psi.
2. Be sure cell components, especially the screen, are clean and dry. Check gaskets and discard any that are worn or distorted.

3. Assemble filtration cell (as illustrated in Figure 8). Lock cell bottom into position by turning cell body until peg locks into J slot.
4. Pour mud sample to within 1/2 in. of top of cell. Place cell onto filter press rack.
5. Position cell lid onto top of cell body. To seal, turn filter press handle clockwise until hand-tight.
6. Place a clean, dry graduated cylinder under the drain tube of the filtration cell assembly.
7. Close bleeder valve. Maintain in the closed position while test is running (Figure 9).
8. Set interval timer for 30 minutes. Open valve located on filter press manifold by turning black knob counterclockwise. Pull timer arm down and begin timing immediately.
9. At the end of 30 minutes, remove graduated cylinder. Measure and record filtrate volume collected. Volume is measured in cm3 per 30 minutes. Close valve by turning black knob clockwise. Open bleeder valve and release trapped line pressure.

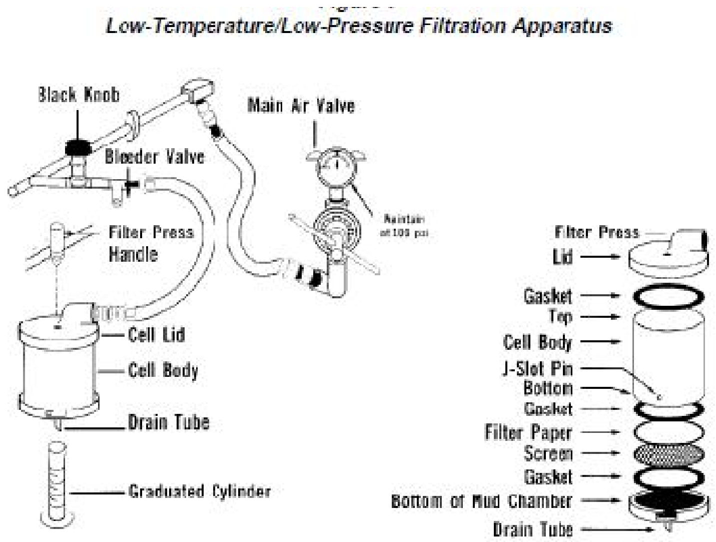


Figure 11: Low-Temperature/Low Pressure Filtration Apparatus

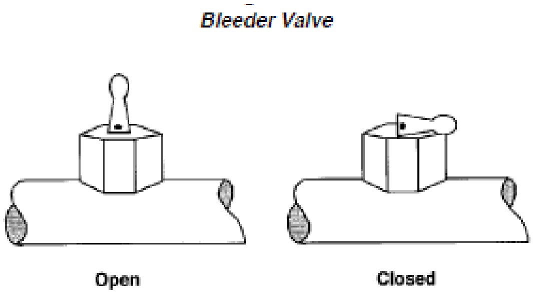


Figure 12: Bleeder Valve

10. Turn filter press handle counterclockwise to remove filtration cell assembly from frame. Pour mud back into viscosity cup, then carefully disassemble mud chamber.
11. Remove filter paper from screen, being careful not to disturb mud cake. Gently wash excess mud from cake with a stream of water.
12. Measure and report thickness of filter cake to nearest 1/32 of an inch. Describe cake; i.e., soft, tough, rubbery, firm, etc.

d) Determine the effect of surfactant on API FL after hot rolling at various temperatures with various concentrations.

In this experiment, API fluid loss result for three base mud, employing PAC-L, CMC-LV and starch for fluid loss control will be investigated. The result will be obtained before and after hot rolling for various temperatures with and without 5% v/v addition of surfactant**.** The experiment will be conducted for 16 hour for every drilling fluid (sample solutions) at various temperatures. The test procedure will be conducted as follows;

1. Place the mud sample full into the cup of hot rolling oven and closed properly using the cup cover.
2. Make sure the cover is tightly closed and make sure there is no leaking. If there is any leaking, replaces the rubber of the cup cover.
3. Put the cup into hot rolling oven and let it roll the cup at the setup temperature for 16 hours.
4. After 16 hours, test and compare the properties of the mud after and before hot rolling. Identify any changes of the mud properties.

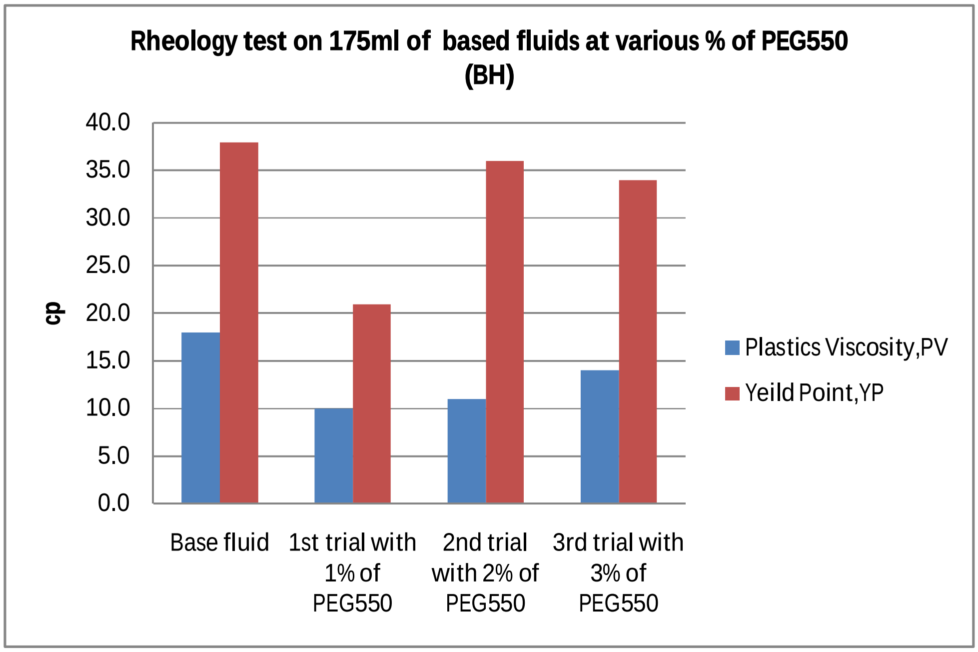
3.6 RESULTS AND DISCUSSIONS

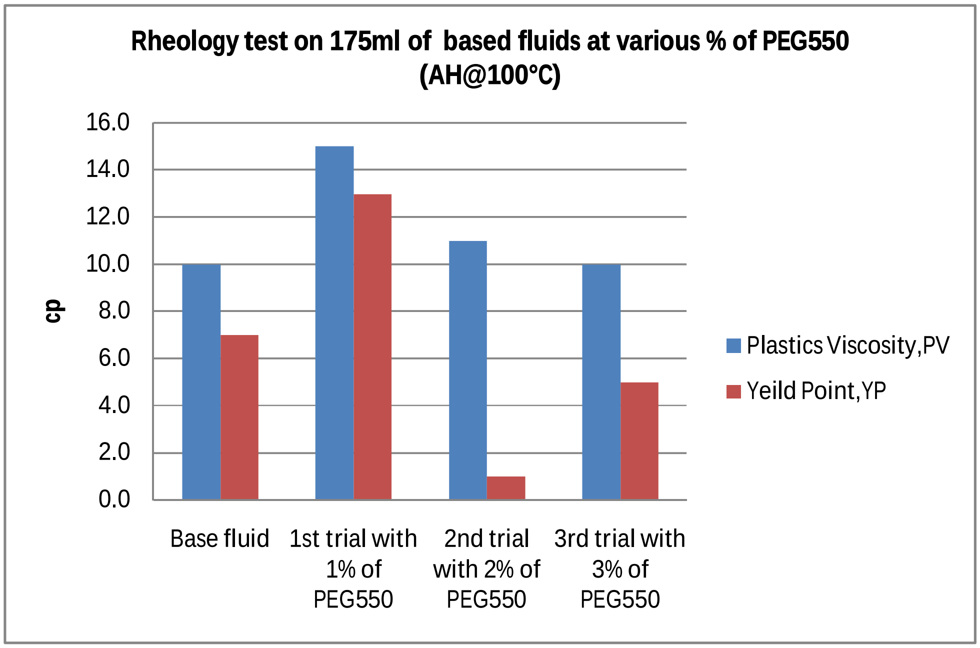
3.6.1-Test on based fluid at various concentrations of PEG550

Results:

Table 7: Results on Based Fluid

Test result/Mud properties	Base fluid		1st trial with 1% of PEG550		2nd trial with 2% of PEG550		3rd trial with 3% of PEG550	
	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C
Viscosity at 600rpm	74.0	27.0	41.0	45.0	58.0	23.0	62.0	25.0
Viscosity at 300rpm	56.0	17.0	31.0	30.0	47.0	12.0	48.0	15.0
Viscosity at 200rpm	52.0	9.0	19.0	25.0	35.0	9.0	44.0	9.0
Viscosity at 100rpm	41.0	13.0	14.0	15.0	33.0	5.0	37.0	7.0
Viscosity at 6rpm	20.0	1.0	7.0	3.0	16.0	1.0	19.0	2.0
Viscosity at 3rpm	17.0	0.5	6.0	2.0	14.0	0.5	16.0	1.0
PV(cp)	18.0	10.0	10.0	15.0	11.0	11.0	14.0	10.0
YP(lb/ft^2)	38.0	7.0	21.0	15.0	36.0	1.0	34.0	5.0
YP:PV	2.1	0.7	2.1	1.0	3.3	0.1	2.4	0.5
Gel strength 10 sec (lb/ft^2)	19.0	1.0	9.0	2.0	15.0	1.5	16.0	1.0
Gel strength 10 min (lb/ft^2)	21.0	2.0	11.0	3.0	13.0	2.0	18.0	1.0
pH	7.09	6.29 @ 34.8°C	6.72	4.36 @ 29.1°C	6.50	4.00 @ 27.1°C	6.37	4.07 @ 32.5°C
Fluid loss after 30min (ml)	TLC	TLC	TLC	TLC	TLC	TLC	TLC	TLC


Rheology test on 175ml of based fluids at various % of PEG550 (BH)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
cp
Base fluid
1st trial with 1% of PEG550
2nd trial with 2% of PEG550
3rd trial with 3% of PEG550
Plastics Viscosity,PV
Yeild Point,YP


Rheology test on 175ml of based fluids at various % of PEG550 (AH@100°C)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
cp
Base fluid
1st trial with 1% of PEG550
2nd trial with 2% of PEG550
3rd trial with 3% of PEG550
Plastics Viscosity,PV
Yeild Point,YP

Discussions:

The experiments performed to test the rheology of based fluid for both before and after hot rolling at 100°C. The based fluid rheology would figure out the properties if the mud to be produced. From the experiment, the based fluid with 0% of PEG550 shows 18cp of PV value and 38lb/ft² of YP value. From those values, the ratio of YP to PV is 2.1. This based fluid has met the project requirements as it has PV value in the range of 15 to 30 and YP value in the range 15-40. After hot rolling at 100°C, the PV value drop to 10cp and YP value drop to 7 lb/ft². However, the ratio of YP to PV is still under 3, which is 0.7.

For the next sample, the based fluid added with 1% of PEG550. It has PV value at 10cp and YP value at 21 lb/ft². The YP to PV ratio is still acceptable which is 2.1. After hot rolling at 100°C, the PV value change to 15cp and YP change to 15 lb/ft². The changes have brought the YP to PV ratio drop to 1.0 and the properties of this based fluid remain in the acceptable range.

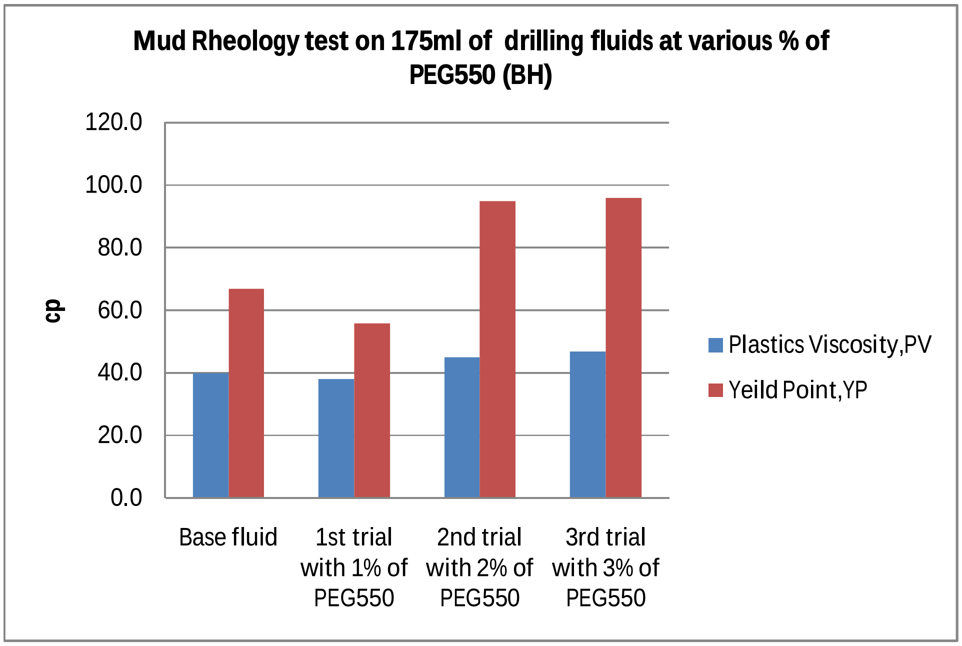
The third result is from based mud with addition of 2% of PEG550. It has about same PV to the previous sample, which is 11cp. But the YP value is higher as it is 36 lb/ft². The ratio of YP to PV is higher than 3. After hot rolling at 100°C, PV and YP to PV value drop dramatically. The YP has drop from 36lb/ft² to 1 lb/ft².The last based fluid has added with 3% of PEG550 give PV value at 14cp and PV value at 34 lb/ft². Both values have met the range and YP to PV still lower than 3. However, they decreased after hot rolling at 100°C. The PV value becomes 10cp and YP value becomes 5lb/ft².

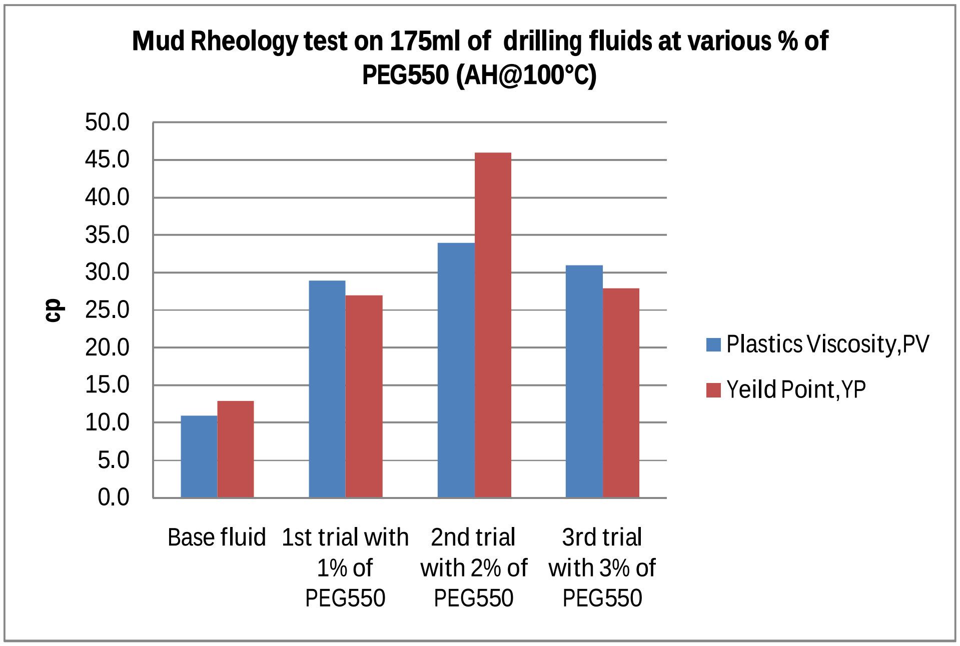
3.6.2-Test on drilling mud at various concentration of PEG550

Results:

Table 8: Results on Mud Tested

Test result/Mud properties	0% of PEG550		1st trial with 1% of PEG550		2nd trial with 2% of PEG550		3rd trial with 3% of PEG550	
	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C
Viscosity at 600rpm	147.0	35.0	132.0	85.0	185.0	114.0	190.0	90.0
Viscosity at 300rpm	107.0	24.0	94.0	56.0	140.0	80.0	143.0	59.0
Viscosity at 200rpm	94.0	19.0	80.0	44.0	120.0	71.0	119.0	47.0
Viscosity at 100rpm	61.0	14.0	55.0	29.0	81.0	48.0	84.0	31.0
Viscosity at 6rpm	17.0	5.0	25.0	7.0	22.0	18.0	24.0	9.0
Viscosity at 3rpm	13.0	2.0	15.0	5.0	16.0	10.0	18.0	4.0
PV(cp)	40.0	11.0	38.0	29.0	45.0	34.0	47.0	31.0
YP(lb/ft²)	67.0	13.0	56.0	27.0	95.0	46.0	96.0	28.0
YP:PV	1.7	1.2	1.5	0.9	2.1	1.4	2.0	0.9
Gel strength 10 sec (lb/ft²)	13.0	3.0	24.0	14.0	16.0	9.0	17.0	4.0
Gel strength 10 min (lb/ft²)	18.0	3.0	20.0	18.0	20.0	13.0	21.0	7.0
pH	8.29 @ 41.4°C	8.23 @ 30.0°C	8.56 @ 32.4°C	7.25 @ 41.4°C	8.08 @ 35.2°C	7.36 @ 38.2°C	7.97 @ 32.6°C	7.81 @ 38.1°C
Fluid loss after 30min (ml)	5.3	5.7	5.4	9.7	4.7	7.6	4.8	18.0
Mud thickness, mm	1.16	1.4	1.61	3	2.48	3.42	2.17	2.19


Mud Rheology test on 175ml of drilling fluids at various % of PEG550 (BH)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
cp
Base fluid
1st trial with 1% of PEG550
2nd trial with 2% of PEG550
3rd trial with 3% of PEG550
Plastics Viscosity,PV
Yeild Point,YP


Mud Rheology test on 175ml of drilling fluids at various % of PEG550 (AH@100°C)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
cp
Base fluid
1st trial with 1% of PEG550
2nd trial with 2% of PEG550
3rd trial with 3% of PEG550
Plastics Viscosity,PV
Yeild Point,YP

Discussions:

The experiments then repeated to test the mud prepared for both before and after hot rolling at 100°C. The muds tested have different concentration of PEG550. The first mud without PEG550 has PV value at 40cp and YP value at 67lb/ft². The YP to PV ratio is acceptable, which is 1.7 and it is below 3. After hot rolling at 100°C, the PV value decreased to 11cp and YP value decreased to 13lb/ft². This changes explains us how the heat affect the mud rheology.

The experiment repeated using mud with addition of 1% of PEG550. Before heating, PV value is 38cp and YP value is 56lb/ft². This mud has YP to PV ratio at 1.5 and it is acceptable for this project. Then, the mud pass through hot rolling process at 100°C and the rheology properties have changes. The PV value decreased to 29cp and YP value drop to 56 lb/ft². However, the YP to PV ratio remains acceptable which is 0.9.

The next mud has an additive of 2% of PEG550. From the rheology test, PV value is 45cp and YP value is 95 lb/ft². After hot rolling at 100°C, both values has drop as the PV changes to 34cp and YP value change to 46 lb/ft². The last mud prepared with addition of 3% PEG550 and tests the rheology properties. This mud has PV value at 47cp before heating. It changes to 31cp after heating. This decreasing is due to the pressure and temperature during hot rolling. Same goes to YP value, it has drop from 96 lb/ft² to 28 lb/ft².

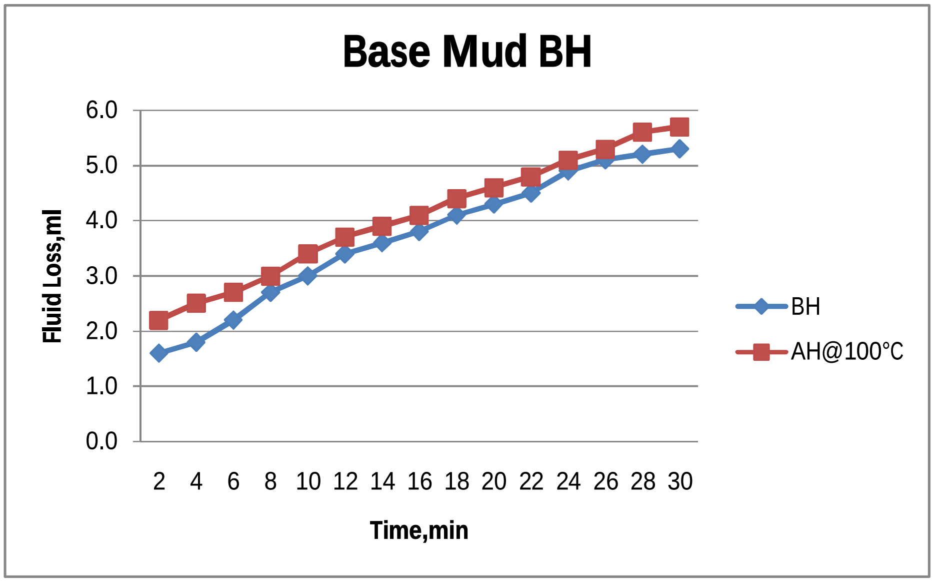
The mud properties changes with the addition of PEG550. PV and YP values are increased with the increasing of concentration of PEG550. The amounts of filtration loss are about the same, which is about 5.0ml. The lowest is mud with 2% of PEG550, which is at 4.7ml. The highest is the mud without PEG550, which is at 5.8ml. Before hot rolling, it shows the increasing of PEG550 concentration, the fluid loss volume decreased. After hot rolling, the volume of fluid loss increased. The lowest volume of filtration loss is from mud with 3% concentration PEG550.

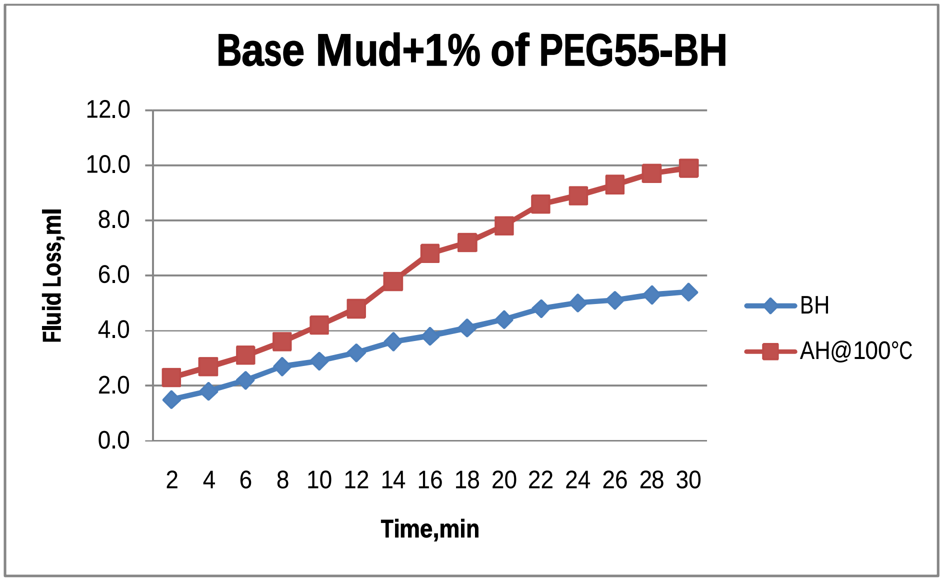
3.6.3-Fluid Loss Test on drilling mud at various concentration of PEG550

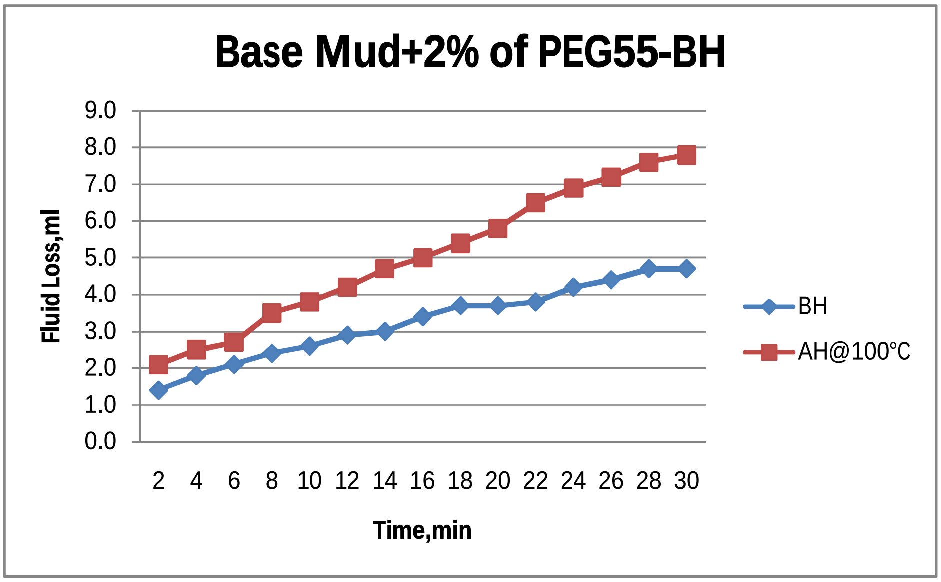
Results:

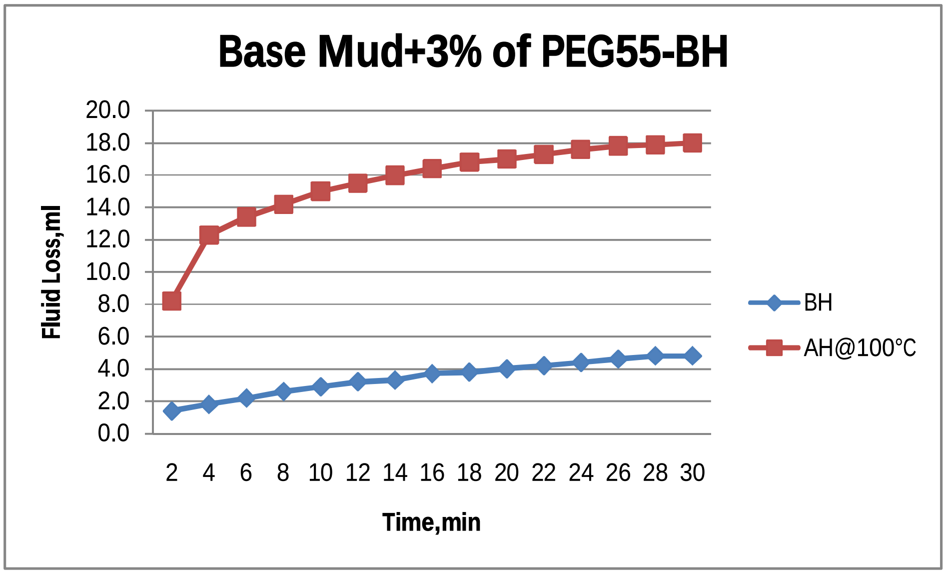
Table 9: Fluid Loss Results

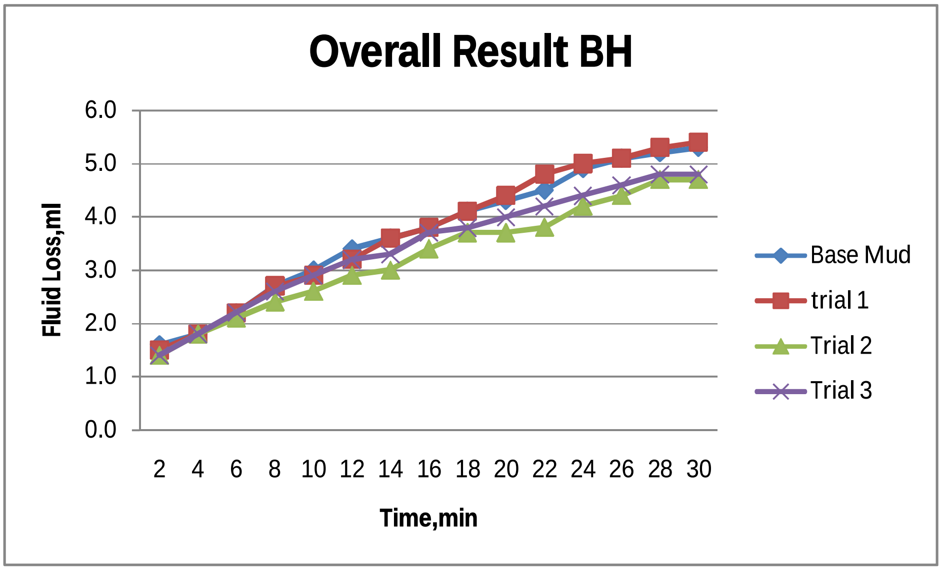
Test result at time,min	Fluid loss,ml							
	0% of PEG550		1st trial with 1% of PEG550		2nd trial with 2% of PEG550		3rd trial with 3% of PEG550	
	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C	BH	AH@100°C
2	1.6	2.2	1.5	2.3	1.4	2.1	1.4	8.2
4	1.8	2.5	1.8	2.7	1.8	2.5	1.8	12.3
6	2.2	2.7	2.2	3.1	2.1	2.7	2.2	13.4
8	2.7	3.0	2.7	3.6	2.4	3.5	2.6	14.2
10	3.0	3.4	2.9	4.2	2.6	3.8	2.9	15.0
12	3.4	3.7	3.2	4.8	2.9	4.2	3.2	15.5
14	3.6	3.9	3.6	5.8	3.0	4.7	3.3	16.0
16	3.8	4.1	3.8	6.8	3.4	5.0	3.7	16.4
18	4.1	4.4	4.1	7.2	3.7	5.4	3.8	16.8
20	4.3	4.6	4.4	7.8	3.7	5.8	4.0	17.0
22	4.5	4.8	4.8	8.6	3.8	6.5	4.2	17.3
24	4.9	5.1	5.0	8.9	4.2	6.9	4.4	17.6
26	5.1	5.3	5.1	9.3	4.4	7.2	4.6	17.8
28	5.2	5.6	5.3	9.7	4.7	7.6	4.8	17.9
30	5.3	5.7	5.4	9.9	4.7	7.8	4.8	18.0

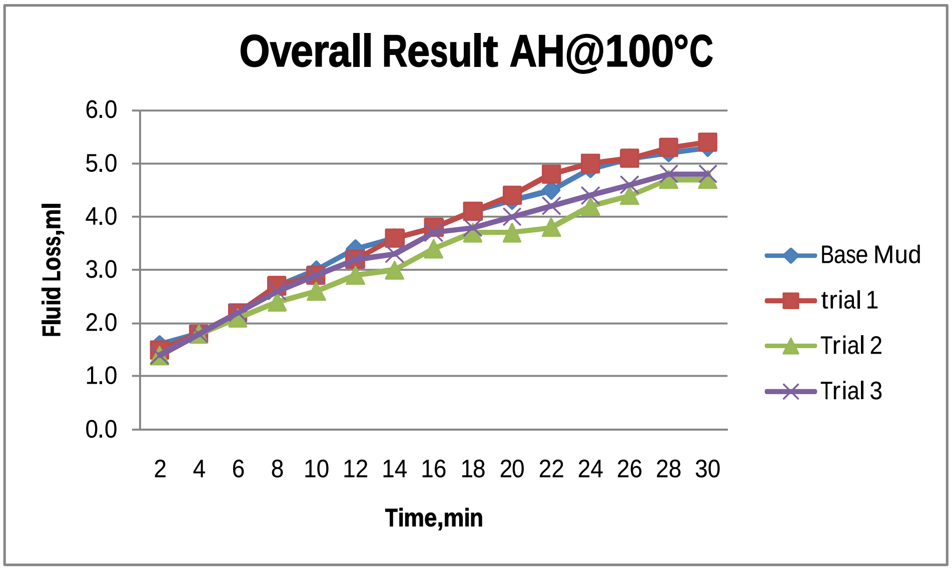

Base Mud BH
Fluid Loss,ml
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
BH
AH@100°C


Base Mud+1% of PEG55-BH
Fluid Loss,ml
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
BH
AH@100°C


Base Mud+2% of PEG55-BH
Fluid Loss,ml
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
BH
AH@100°C


Base Mud+3% of PEG55-BH
Fluid Loss,ml
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
BH
AH@100°C


Overall Result BH
Fluid Loss,ml
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
Base Mud
trial 1
Trial 2
Trial 3


Overall Result AH@100°C
Fluid Loss,ml
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Time,min
Base Mud
trial 1
Trial 2
Trial 3

Discussions:

The first test conducted using based mud only and it shows that the based mud has total fluid loss at 5.3ml. After hot rolling at 100'C for 16 hours, the value increase to 5.7ml. This shows that the based mud cannot withstand the heat during hot rolling and it original properties have changed. The amount of the fluid loss has increase. The test continued using based mud with addition 1% of PEG550. Total fluid loss is 5.4 which is 0.1ml greater than the based mud. After hot rolling process, the value has increased to 9.9ml. This shows that the mud is not really stable at the temperature.

The next test performed using based mud with addition 2% of PEG550. Before hot rolling process, it shows positive change as it has lower total fluid loss than the based mud before. The fluid loss has decreased to 4.7ml. From here, we observed that the PEG550 has change slightly on the mud properties. However, after hot rolling, it has increased to 7.8ml. 2% of PEG550 has affect only before heating but not really performed after hot rolling. The final test on based mud with addition 3% of PEG550 has give total fluid loss at 4.8ml before hot rolling. it is lower than based mud without PEG550 and this is good indicator for the affect of the surfactant on drilling fluid. Then, after hot rolling at 100'C, the total fluid loss has increased to 18ml. this shows the surfactant cannot really performed after hot rolling.

From the overall result, most of them has initial fluid loss in the range of 1.3ml to 2.5ml accept for the mud with 3% of the surfactant. After hot rolling, the mud with 3% of the surfactant has low poor fluid loss. It shows 18ml of fluid loss in the first minutes during the test. This shows the excess amount of PEG550 would reduce the performance of the mud. The excess amount of PEG550 only performed before hot rolling, but not after hot rolling process. However, the best performance has been achieved by the mud with 2% of PEG550. It shows the lowest total fluid loss before hot rolling, and it is 4.7ml. After hot rolling, the value increase, but still the lowest one among the mud with PEG550.

CONCLUSIONS

In conclusion, the current result has show the affect of PEG550 on the surfactant and its benefits for this field. The PEG550 has working perfectly on the mud before hot rolling. It has reduced the amount of fluid loss and keeps the mud rheolgy properties such as yield point, plastics viscosity, and gel strength in acceptable range. The affect of the surfactant on the frilling fluid has been investigated. The PEG550 has ability to retain mud rheology before and after hot rolling.

The second objective also has been achieved from the lab evaluation process. From the rheology test until the fluid loss test, the best amount to be added has been achieved. It is prove the actual theory from the PEG studies as the surfactant can only performed at certain amount on the drilling fluid. The excesses amount of the surfactant would reduce the performance of the mud especially at higher temperature. From the lab test, the suitable amount of PEG550 to be added in the mud formulation is 2%.

Finally, the project has successfully performed based on the both objectives. The further studies can be implemented to increase the potential of the surfactant to be using in this field. The surfactant can be test on other various types of mud in term of the mud rheology, fluid loss, mud stability, and even marketability. This type of surfactant has bright future to be applied in drilling operation or even form chemical EOR as it is already widely used in other industries.

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