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RESEARCH ON EVALUATING SYNTHETIC HTHP FLUID LOSS REDUCER IN VARIOUS OIL BASE DRILLING FLUIDS

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CERTIFICATION OF APPROVAL

Evaluation on Performance of HTHP Fluid Loss Reducer in various Base-Oil

by

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11566

Supervisor: Ms. Raja Rajeswary Suppiah

A project dissertation submitted to the
Petroleum Engineering Programme
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In partial fulfilment of the requirement for the
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(Petroleum Engineering)

Approved by,

____

(Raja Rajeswary Suppiah)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2012

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 acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

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ABSTRACT

Nowadays every company in oil and gas industries is focusing in deep water well technology. Those who dominate these technologies upfront will conquer this industry and that is how its work. Basically, deep water well drilling need drilling fluids that can withstand in HTHP conditions and oil base will be the selection of the drilling fluids rather water base drilling fluids. One of the additives in oil base drilling fluids is HTHP fluid loss reducer that functions as small particles that bridging the pore opening in mudcake to reduce mud filtrate. Research work on performance of synthetic HTHP fluid loss reducer in various types of oil base mud have a solid objective which is to evaluate the performance of various types of HTHP fluid loss reducer in various types of oil base mud. By using four different types of synthetic oil base which are *Sarapar 147, Saraline 185,* and *Escaid 110* the research will be done in terms of evaluating and comparing the performance each of these synthetic oil base as its rheology properties and behaviors in HTHP conditions and the performance each of its when applying different types of HTHP fluid loss reducer which includes of *Confi-Trol F* and *Confi-Trol XHT*. The data collected from the experiments, will then lead to the formulating new HTHP fluid loss reducer as a new innovation in this area. It seems to have commercial value in this projects and one of the oil and gas company are willingly to involve in consulting the project.

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(Muhammad Zulhilmi Bin Abdul Rahman)

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ABBREVIATION

List of abbreviation:

OBM	Oil Based Mud
SBM	Synthetic Based Mud
WBM	Water Based Mud
SBF	Synthetic Base Fluid
HTHP	High Temperature High Pressure
H_2S	Hydrogen Sulfide
CO_2	Carbon Dioxide
N_2	Nitrogen
YP	Yield Point
MW	Mud Weight
RPM	Revolution Per Minutes
API	American Petroleum Institute
SPE	Society Petroleum Engineer

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CHAPTER 1

INTRODUCTION

The drilling engineer is concerned with the selection and maintenance of the best drilling fluid for the job. The drilling fluid is related either directly or indirectly to most drilling problems. If the drilling fluid does not perform adequately of its functions, it could become necessary to abandon the well. Thus, some additives required to maintain the drilling fluid in a good condition.

1.1 BACKGROUND OF STUDY

An HTHP Fluid Loss Reducer principle is bridging the pore openings with rigid or semi-rigid particles of sufficient size and number. This particle is reducing the volume of fluid loss into the formation from the mudcake [3,10]. A quick and effective particle bridge will limit particle invasion to maximize return permeability. However, in order to ensure that the filter cake can be effectively removed after placing the well in production, it must meet two important requirements: The fluid must possess the right particle size distribution and particle concentration to build a filter cake that will quickly and effectively bridge the pore openings. The fluid must deposit a filter cake that is highly dispersive to the produced fluid.

In this research, the evaluation to find the right OBM for the right HTHP Fluid Loss Reducer is necessary to provide information for maximizing the application of HTHP Fluid Loss Reducer in HTHP wells. Prior to the limited resources, several types of OBM are selected for this research which is *Saraline 185*, *Sarapar 147*, and *Escaid 110* which will be provided by SCOMI OilTools. In other hand, the HTHP Fluid Loss Reducer that are been selected for the research purposes are *Confi-Trol F* and *Confi-Trol XHT*.

1.2 PROBLEM STATEMENT

Application of oil base mud basically only in high temperature and high pressure well due to environmental issue and also the cost of it usage. There are many types of oil base mud that commercially being used in oil and gas industry and some of it were different in name depending on the producing company. These types of oil base mud not just only different in the name but also the performance in term of mud rheology for HTHP wells. Thus, enough information on the performance of these base-oils in HTHP wells is necessary for implementation in real cases applications.

As we know that different oil base have different characteristics. The most important parameter that will be taken into consideration in this research is pressure and temperature. Basically this research is about HTHP well so, the performance of base oil will be depending on high temperature and high pressure until to extend at which the base oil perform well. Using additive such as fluid loss reducer can create an extension of these base-oils to another higher temperature and pressure in wells. In this project, this product of Scomi OilTools which is *Confi-Trol XHT* is compared with *Confi-Trol F* in term of ability to withstand higher degree of temperature and pressure than to the existing products.

Currently, there are various types of HTHP fluid loss reducer that are being used in drilling fluid for HTHP well applications. But none research has develop to provide information of these HTHP fluid loss reducer performances in different types of base oil and there is also none research on differentiating in term of evaluating the performance among these types of HTHP fluid loss reducer that are being used nowadays in this industry.

1.3 PROJECT OBJECTIVES

The first objective of this research is to establish an evaluation and comparison on the performance of various types of base oil that will be selected according of its suitability usage in HTHP wells. Generally, the evaluations are based on the mud rheology properties such as yield point, gel strength, viscosity, mud weight, HTHP fluid loss, emulsion stability and so on to compare the performance in elevated pressure and temperature.

The second objective is to evaluate the ability of mud in terms of mud rheology performance in elevated high temperature and high pressure by using different HTHP fluid loss reducer. Basically, it is to prove that *Confi-Trol XHT* can withstand higher HTHP wells condition than the *Confi-Trol F*. The evaluation can be observed by comparing the mud rheology for mud using additive *Confi-Trol XHT* and *Confi-Trol F*.

The third objective is to evaluate the performance of different types of HTHP fluid loss reducer in every types of base oil to analyze the suitability of the HTHP fluid loss reducer with the base oil. It is due to the characteristics of base oil will react with this additive so, it should have evaluations on which type of HTHP fluid loss reducer that react better in specific type of base oil.

From this research, hopefully the information provided can initiate the next research for more types of additive, not just only fluid loss reducer, and also information on all base-oils that exists nowadays. Hence, become a reference for mud engineer to make better choice in well enhancement and able to produce exceptional rate without damaging the wells.

1.4 SCOPES OF PROJECT

Scope of studies for this research is on mud properties which are to observe the performance of HTHP fluid loss reducer in different types of oil-base mud. Basically, the result will be on the mud rheology characteristics; viscosities, gel strength, yield point, HTHP fluid loss, mud weight, and emulsion stability. Even though it is required for all these data on mud rheology to determine the path of this research, but HTHP fluid loss will be the main focusing subject due to the main objective of this research is to evaluating the performance of the additive of HTHP fluid loss reducer in oil base mud. The rheological behavior is to indicate the performance of drilling fluid in hole cleaning and hole erosion, suspension of drill cutting, hydraulic calculation, fluid loss, and requirement of drilling fluid treatment in HTHP wells. The viscosity is focusing on plastics viscosity to indicate the drilled cuttings suspension and hole cleaning abilities under dynamic condition. [1]

1.5 FEASIBILITY ANALYSIS

Feasibility analysis is a guidance to identify the possible risks that would be gained if the project is approved. First, is important to be familiar with the functional area. In order to develop new HTHP fluid loss reducer, the author must know well about the scope of studies so that the author can gather all the data correctly within timeframe. The author also must know the procedure of lab testing correctly to get better result. Next, it is about familiarity with technology which means the author must know well about the technology is used. Considering the scopes of studies only focusing on mud properties, it can be done in UTP laboratory and the author believes that the timeframe to complete the research is enough within one semester. For organizational feasibility, the author already get help from one of oil and gas company in consulting to lead this research as it has the commercial value that the company is looking forward to it. Thus, it can be said that, this research is feasible to carry on and maybe can become as a starting point in oil and gas industry evolution.

1.6 RELEVANCY OF PROJECT

In terms of the relevancy of this project, it poses a great deal of significance to the oil and gas industry. The application of HTHP fluid loss reducer in deep water drilling create total evolution in order to create higher success rate in drilling wells especially in HTHP wells. So, to come out with new HTHP fluid loss reducer formulation can be commercialize globally in oil and gas industry is undisputed necessary. This might be the first step to create more studies and research on this additive to create a better performance and economical HTHP fluid loss reducer. The question is how well this HTHP fluid loss reducer performs in HTHP conditions and the comparison to each other of the existing one to come out any improvement from the old one. So, this research basically to fill up the purposes of evaluating this additive to observe its performance before applying it into the real applications.

For this project, the author is applying his theoretical and practical knowledge in petroleum engineering to evaluating analytical and theoretical on HTHP fluid loss reducer performance, base oil performance and to analyze the substances in this products so the author establish the milestone in creating new formulation of this product. The basic principle involved range from drilling fluid study, well completion and production, thermodynamics, facilities engineering and management of drilling fluid. Hence, this study seems to be fit as a platform for the author in applying his petroleum engineering knowledge and skills. The outcome of this research is deemed crucial towards providing future technology in drilling fluid application in future.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The drilling fluid creates a filter cake that imparts low permeability to the face of the permeable formation. The ideal filter cake comprises a relatively thin and hard layer as opposed to thick viscous coating. Pressure in the bore hole exceeds the pressure in the permeable formation and thereby creates the filter cake which further results in liquid from the drilling fluid moving into the permeable formation. This leaves a layer of the filter cake on the face of the hole. Liquid permeating this filter cake and the formation is called filtrate. As the thickness of the filter cake increases, the volume of the fluid loss also increases. [10] The problem is premature mudcake that build up too early in the mud circulation process. This situation can cause several problems occur such as toolstrings stuck in borehole. The function of the fluid loss control agents is to delay, prevent or at least limit as far as possible fluid losses that may be sustained by the drilling fluids during the drilling operation.

2.2 DRILLING FLUID

Drilling fluid is used in the rotary drilling process to clean the rock fragments from beneath the bit and carry them to the surface, exert sufficient hydrostatic pressure against subsurface formations to prevent formation fluids from flowing into the well, keep the newly drilled borehole open until steel casing can be cemented in the hole, and cool and lubricate the rotating drillstring and bit. In addition to serving these functions, the drilling fluid should not have properties detrimental to the use of planned formation evaluation techniques, cause any adverse effects upon the formation penetrated, or cause any corrosion of the drilling equipment and subsurface tubulars.

The main factors governing the selection of drilling fluids are the types of formations to be drilled, the range of the temperature, strength, permeability, and pore fluid pressure exhibit by the formations, the formation evaluation procedure used, the water quality available, and ecological and environmental considerations. However to a large extent, the drilling fluid usage that yields the expendable cost usually determined by trial and error. Water-based mud is most commonly used in drilling fluids. But it is restricted to the area with lower temperature and lower pressure due to the inconsistency mud rheology in high temperature. Oil-based muds are generally is limited to drilling extremely hot formations or formations that are affected adversely by water-based muds due to its costs and require more stringent pollution control procedures than water-based muds. The use of gases as drilling fluids is so rare and is limited to areas where the formations are competent and impermeable.[2] Gas or liquid mixtures can be used when only a few formations capable of producing water at significant rates are encountered.[2]

In order to increase daily crude oil production, oil and gas industry has been emerging deep water drilling and it is normally associated with HTHP condition. Therefore oil-base mud being chosen as drilling fluid due to its excellent thermal-stability characteristic, inherent protection against acid gases and corrosion, capability of drilling water soluble formation with little or no water washout problem, improve lubricity that indirectly assists in drilling deviated or high angle holes and reduced stuck pipe problem, and ability drilled in water sensitive shale sections and thus preventing over-gauge hole problem[4].

2.3 BASE OIL

2.3.1 Base Oil

Hydrocarbon oils are the continuous phase in oil-base fluids. They are non-polar, low-surface tension liquids and interact only weakly with mineral solids. This characteristic is the basis for the use of oil-base fluids as non-reactive, inert drilling fluids. The most commonly used oils today are synthetics where certain environmental regulations prevail, low-aromatic-content, low-toxicity mineral oils, and No. 2 diesel oil. [7]

Crude oil has been used in the past but finds little application in today's modern day oil-mud drilling fluids. Crude is relatively cheap, often available, but may need topping to minimize flammability since a flash point greater than 180°F (82°C) [3,4,5] is advised. Crude contains native asphaltenes and resins which can interfere with other additives.

No. 2 diesel oil is a moderately-priced, commonly available distillate which contains none of the native asphaltenes or resins in crude and is the most commonly used oil for mixing oil-base fluids.[7] The aromatics in diesel oil can swell rubber gaskets, seals, and pipe rubbers, however, an aniline point greater than 140°F (60°C) (the higher the aniline point, in general, the lower the concentration of aromatics)[4] is recommended.

Synthetic-base drilling fluids (SBF) use a synthetic type material as the continuous phase. Synthetics are the preferred oil in offshore drilling operations where environmental regulations prohibit the discharge of cuttings and/or whole mud to the sea. Unlike mineral and diesel oils which are distilled from crude oils, synthetic type materials are usually polymerized from ethylene. Since the synthetics are pure products made from ethylene, they contain no aromatics, thereby lowering the toxicity level normally associated with aromatic compounds. Like hydrocarbon oils, the synthetic type materials are more viscous than water.[7]

Oil	Density at 60°F (15°C) (g/ml)	Initial Boiling Point	Final Boiling Point	Flash Point	Aniline Point	Aromatic Content (wt. %)	Viscosity at 104°F (40°C) (cSt)
Diesel	0.84	383°F 195°C	734°F 390°C	149°F 65°C	154°F 68°C	25 %v/v	3.4
ISO-TEQ C16-18 (SYN-TEQ sys.)	0.792	>518ºF >270ºC	NA	273ºF 134ºC	180ºF	NA	3.6
Exxon ESCAID 110	0.806	394°F 201°C	459°F 237°C	167°F 75°C	162°F 72°C	0.05	1.63
SIPDRILL 2/0 (PARA-TEQ sys.)	0.760	412ºF 211ºC	455°f 235°C	203ºF 95ºC	189ºF 87°C	< 0.1	1.75
Total HDF2000	0.808	450°F 232°C	622°F 328°C	221°F 105°C	192°F 89°C	0.4	3.3
Conoco LVT200	0.820	421°F 216°C	518°F 270°C	201°F 94°C	166°F 74°C	1.0	2.1
ALPHA-TEQ	0.778	437°F 225°C	518°F 270°C	237°F 114°C	147°F 64°C	0.1	2.06
EDC 99 DW	0.811	448°F 231°C	509°F 265°C	214°F 101°C	176° 80°C	0.0	2.28
SARAPAR 147	0.76 @ 30°c	NA	NA	248°f 120°C	90°C	NA	2.6

Table 1: Base Fluid Properties

2.3.2 OBMs Basic Chemistry

Oil mud require special to ensure that the emulsion is extremely stable and can withstand conditions of high temperature and contaminants. Every single product must be dispersible in the external oil phase. [3,4,7,8]

Emulsifying systems	Calcium soaps are the primary emulsifier in oil muds. These are made in the mud by reaction of lime and long-chain fatty acids. Soap emulsions are strong emulsifying agents but may take reaction time before emulsion is actually formed. Thus secondary emulsifiers are used: they consist in very powerful oil-wetting chemicals which generally do not form emulsions but wet solids before the emulsion is formed. Also used to prevent from any water intrusion.

Lime	Lime is essential in OBMs. It neutralizes fatty acids in the fluid, stabilizes the emulsion when present in excess, and controls alkalinity. In the field, it also neutralizes acid gases such as H_2S and CO_2.
HTHP fluid loss reducer	Many types of chemicals can be used as fluid loss control agents. They are usually organophilic lignites (amine-treated lignites), Gilsonite or Asphalt derivatives, or specialpolymers (polyacrylates)
Wetting agents	Supplemental additives to quickly and effectively oil-wet solids that becomes water-wet.
Chemicals to control rheology	Additives that build the viscosity of the mud. Bentonite, hectorite or attapulgite, treated with amine to make them oil-dispersible, are commonly used organophilic gellants. When their properties are reduced by high temperature, polymeric viscosifiers are added. Other rheology modifiers increase the viscosity at low shear without increasing total mud viscosity, e.g. low molecular weight fatty acids. Deviated wells are good conditions of use for such products.
Weighting agents	Used to increase the density of the oil mud. The most commonly used are Calcite (MW up to 10.8 ppg), Barite (MW up to 21 ppg), and Hematite (MW up to 24 ppg).

Table 2: OBMs Basic Additives

2.4 HTHP FLUID LOSS REDUCER

Lost circulation material is added to a mud to control loss of mud into highly permeable sandstones, natural fractures, cavernous formations, and induced fractures. Before a mud filter cake can be deposited, lost circulation additives must bridge across the large openings and provide a base upon which the mud cake can be built. Commonly used as lost circulation additives are asphalt, gilsonite, and pliolite.

2.4.1 Asphalt/Gilsonite

Asphalt is a petroleum-derived colloidal gel composed of colloidal asphaltenes, polar aromatics (resins), and oils (see Figure 1). [7,8]

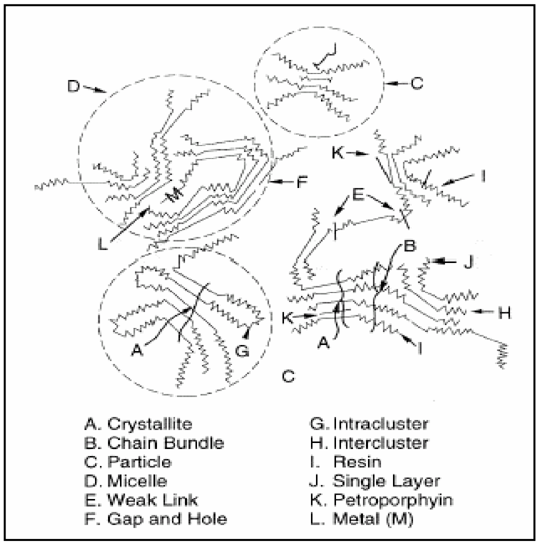


Figure 1: Macrostructure of Asphalt

The most commonly encountered are those that are naturally present in crude, gilsonite (a mined product), and blown asphalt. The active components are the asphaltenes. Quality asphaltenes are highly-associating and form *micelles* which are thermally stable. The primary use of asphalt is for fluid loss control. The concentration used is 1-15 lbm/bbl (2.9 - 42.8 kg/m³). Asphalt also functions as a shale stabilizer at 5-15 lbm/bbl (14.3 - 42.8 kg/m³). When used at higher concentrations, such as ≥ 40 lbm/bbl (114 kg/m³), it functions as a viscosifier by increasing the base fluid viscosity.

2.4.2 Pliolite

A Pliolite resin is based on an organosoluble gel structure that is designed to provide fluid-loss control and to limit formation damage from oil-based fluids under high temperature and high pressure conditions [17]. The ability of the microgel particles to deform under shear allows them to be produced back easily. While the particle is deforming, its shape is modified and its volume is reduced because oil is expelled from the cross-linked core. This ability to deform reduces risks of formation damage in the pay zone. [2, 7, 8, 17]

2.5 RESEARCH PAPER

Up until now, there still no establish research done on this topic, but there are still some research that leads the idea to this related becoming as a references. There is a research related comparing several types of base oil was done by A. T. Ket Seang et al., with the title "The Comparison Of Saraline, Sarapar And Diesel Performances As Base Oil At High Temperature And High Pressure". This research concluded that Sarapar is the most suitable oil base due to its non-degradable capability in rheological properties in HTHP condition. The aromatic and benzene contents are lower in Sarapar base oil compared with diesel and Saraline base oil. [1] Basically, from this research, the most preferred oil base is one with the less aromatic and benzene contents and non-degradable as it does not affected much after ageing period in the wells.[1,8]

Based on the research done by M. Shahjahan Ali et al. on The Effect of High Temperature, High Pressure and Aging on Water-Base Drilling Fluid (July 29, 1990), it is about the investigation the effect of water-based mud in HTHP conditions in term of viscosity, yield point, and gel strength which is the results show a decrease in viscosity, yield point and gel strength with the increase in temperature. In this research shows that, effective viscosity, plastic viscosity, yield point and gel strengths decrease gradually with the increase in temperature for all values of aging time.[9,14] These changes in rheological properties can be explained according to the investigation done by AI-Marhoun and Rahman. [14] According to them, these changes in rheological properties are due to the effect of gypsum and lime added to the mud system. Thus, it gives the idea that somehow, there are limit in pressure and temperature for drilling fluids that affecting the behaviours.

Even though no paper have been published that related to research on HTHP Fluid Loss Reducer in synthetic oil-based mud, eventually, there are some paper that become as references indirectly lead to the studies on this topic.

CHAPTER 3

METHODOLOGY

3.1 RESEARCH METHODOLOGY

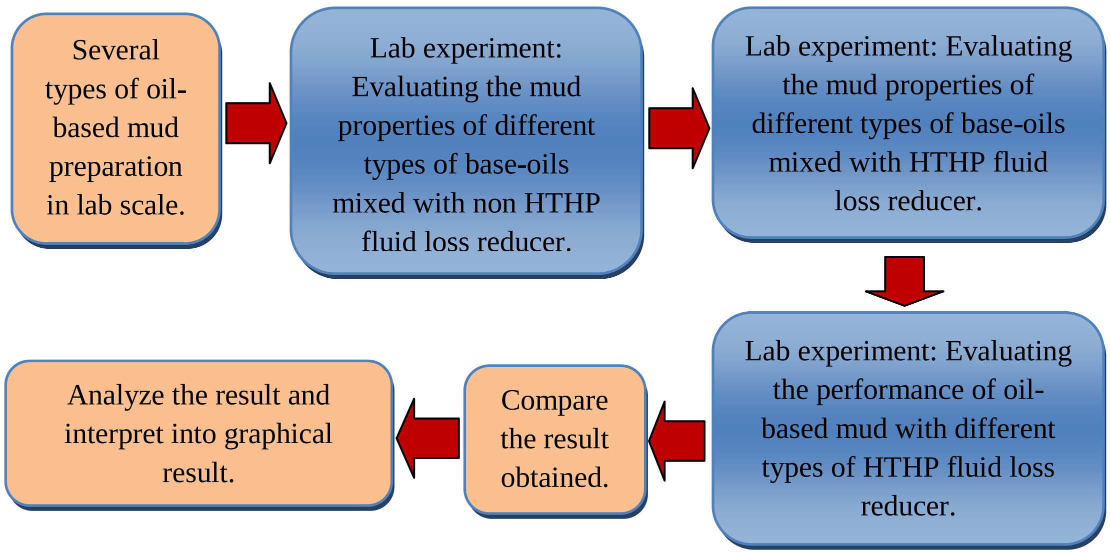


Figure 2: Project methodology

1. Before proceeding with the research, preparation of oil-based mud by using several selected oil base is necessary in the process.
2. The next step is to proceed with mud rheology lab testing for each types of oil-based mud to compare the result as its performance in which for the better usage in real application.
3. Then, perform experiment on the drilling mud in constant high temperature and high pressure to evaluate the performance in application of HTHP wells
4. Several types of HTHP fluid loss reducer that been selected is mixed in drilling mud and then perform the mud rheology testing for each drilling mud.
5. All the data from the lab testing will be gathered to analyze and evaluate as a milestone to proceed with the study on the HTHP fluid loss properties and characteristics.

3.2 PROJECT ACTIVITIES

The initial process is to prepare the drilling fluid to run the test. Then, there will be four stages of lab experiments that consists of experiments for analyzing the differences of rheology properties of different types of oil-based mud, experiments for evaluating the performance of oil-based mud in constant elevated temperature and pressure, experiments for evaluating the performance of oil-based mud with different types of HTHP fluid loss reducer and experiments for formulating HTHP fluid loss reducer with new formulation and evaluate the performance of mud properties.

3.2.1 Procedure of OBM Preparation

The addition of components in their proper sequence when initial mixing an oil mud, will optimize the performance of each product. The order of addition as below is the most common procedure for the preparation of oil-based muds, though each mud system may require some modifications of the procedure. Basically, this is the basic procedure for lab scale:

1) Add the required quantity of base oil to the mixing vessel [*see Appendix 1:figure 10*].
2) Add the primary and secondary emulsifiers as required.
3) Add the organoclay gallant as required.
4) Add filtration control additives
5) Add lime in excess.
6) Add required amount of brine.
7) Mix for a long time to ensure a good emulsion is formed.
8) Add weighting material as required for the desired density.

3.2.2 Experiments for analyzing the differences of rheology properties of different types of OBM

1. **Mud Density Test**

Theory:

The density of the drilling fluid must be controlled to provide adequate hydrostatic head to prevent influx of formation fluids, but not so high as to cause loss of circulation or adversely affect the drilling rate and damaging the formation.

Equipment: Baroid Mud Balance [*see Appendix 1: figure 11*]

Procedure:

1) Remove the lid from the cup, and completely fill the cup with the mud to be tested.
2) Replace the lid and rotate until firmly seated, making sure some mud is expelled through the hole in the cup.
3) Wash or wipe the mud from the outside of the cup.
4) Place the balance arm on the base, with the knife-edge resting on the fulcrum.
5) Move the rider until the graduated arm is level, as indicated by the level vial on the beam.
6) At the left-hand edge of the rider, read the density on either side of the lever in all desired units without disturbing the rider.

2. Mud Viscosity Test

Theory:

Viscosity of a fluid is defined as its resistance to flow and is measured as the ratio of the shearing stress to the shearing strain. The desired viscosity is influenced by several factors, including mud density, hole size, pumping rate, drilling rate, pressure system and requirements, and hole problems. Two types of fluid characterizations are Newtonian (true fluids) where the viscosity is constant, and Non-Newtonian (plastic fluids) where the viscosity is not constant. There are two types of measurement which are for field measurement and laboratory measurement.

Equipment: Marsh Funnel Viscosity (for field measurement) and The FANN Model 35A Viscometer (for laboratory measurement).

Procedure:

<u>The Marsh Funnel Viscosity</u>: [*see Appendix 1: figure 11*]

1) With the funnel in an upright position, cover the orifice with a finger and pour the freshly collected mud sample through the screen into a clean, dry funnel until the fluid level reaches the bottom of the screen (1500 ml)
2) Immediately remove the finger from the outlet and measure the time required for the mud to fill the receiving vessel to the 1-quart (946ml) level.

<u>The FANN Model 35A Viscometer</u>: [*see Appendix 1: figure 12*]

1) Place a recently agitated sample in the cup, tilt back the upper housing of the viscometer, locate the cup under the sleeve (the pins on the bottom of the cup fit into the holes in the base plate), and lower the upper housing to its normal position.
2) Turn the knurled knob between the rear support posts to raise or lower the rotor sleeve until it is immersed in the sample to the scribed line.
3) Stir the sample for about 5 seconds at 600 RPM, and then select the RPM desired for the best.
4) Wait for the dial reading to stabilize.
5) Record the dial reading and RPM.

3. Gel Strength Test

Theory:

The gel strength is a function of the inter-particle forces. An initial 10 seconds gel and 10 minutes gel strength measurement give an indication of the amount of gelation that will occur after circulation ceased and the mud remains static.

Equipment: The FANN Model 35A Viscometer.

Procedure:

1) Stir a sample at 600 RPM for about 15 seconds.
2) Turn the RPM knob to the STOP position
3) Wait the desired rest time (normally 10 seconds or 10 minutes).
4) Switch the RPM knob to the GEL position.
5) Record the maximum deflection of the dial before the Gel breaks, as the Gel strength in lb/100 ft^2.

4. Yield Point Test

Theory:

This is the measure of the electro-chemical or attractive forces in the mud under flow (dynamic) conditions. These forces depend on surface properties of the mud solids, volume concentration of the solids, and electrical environment of the solids. The yield point of the mud reflects its ability to carry drilled cuttings out of the hole.

Equipment: The FANN Model 35A Viscometer.

Procedure:

By means of the viscometer calculations procedure, determine the Apparent and Plastic Viscosities, Yield Point and initial 10 seconds and final 10 minutes Gel Strength parameters.

Yield Point (YP) = 300 RPM – Plastic Viscosity.

5. Emulsion Stability Test

Theory:

Water present in an oil mud is in the form of the emulsion. A chemical emulsifier must be added to prevent the water droplets from coalescing and settling out of the emulsion.

Equipment: The Electric Stability kit. [*see Appendix 3: figure 18*]

Procedure:

1) Before placing the probe in the mud, it is essential to test the meter in air. The reading should go off scale and the display start flashing. If the meter does not go off scale, it is an indication that the probe is shorting out due to an accumulation of detritus between the two prongs. It is clear that the probe can short out before the end point of the mud is reached and an erroneous reading will result. The probe should be carefully cleaned and retested in air to ensure that it now goes off scale before testing the mud.
2) Place the clean and checked probe in the sample at 120˚ F and use it to stir the fluid to ensure homogeneity. Position the probe so it does not touch the bottom or sides of the heated cup, ensuring the tip of the electrode is completely immersed.
3) Press the button to initiate the voltage ramp, holding the probe still until the end point is reached and a steady reading is seen in the digital display. Note the reading.
4) Repeat the test. The two ES values should be within 5% and anything greater would indicate a problem with the equipment.
5) The result is the average of the two readings.

3.2.3 Experiments for evaluating the performance of OBM in constant elevated temperature and pressure.

The FANN Model 75 Viscometer [*see Appendix 2: figure 12*] will be used to evaluating the viscosity, gel strength, and yield point because it capable of measuring viscosity at up to 500 degrees and 500 psi and with a computerized instrument, it capable of measuring viscosity at up to 500 degrees and 20,000 psi. The ability to measure and record viscosities and gel strengths on a regular basis at bottom hole temperature and pressure can mean the difference between success and failure. The procedure will be same by using The FANN Model 35A Viscometer.

3.2.4 Experiments for evaluating the performance of OBM with different types of HTHP fluid loss reducer.

1. **HTHP Filtration Test**

Theory:

Filtration control is one of the primary characteristics of a drilling fluid and fulfils a variety of functions from the prevention of differential sticking to minimisation of formation damage. The loss of liquid from a mud due to filtration is controlled by the filter cake formed of the solid constituents in the drilling fluid. The test in lab consists of measuring the volume of liquid forced through the mud cake into the formation drilled in 30 minutes period under given pressure and temperature using a standard size of cell. This test tends to be run at temperatures that reflect expected bottom hole temperatures and thus the procedures are for temperatures up to 300˚ F.

Equipment: Standard API Filter Press [*see Appendix 2: figure 14*] (for low pressure test of 100±5 psi), HTHP Filter Press [*see Appendix 1: figure 15*] (for high pressure test).

Procedure:

1) Turn on heated jacket at the mains and insert a thermometer into the jacket and leave to preheat to the desired temperature.
2) Check out all the “O” rings on the HPHT bomb and lid.
3) With stem valve closed on bottom of cell, fill up cell with mud to within 0.5” of the ‘O’ ring groove, to allow for thermal expansion.
4) Insert filter paper into the cell followed by the bottom cell plate assembly over the filter paper and twist to align with the safety locking lugs. Ensure the lid stem is open while doing this to avoid damaging the filter paper.
5) Tighten the 6 grub screws evenly using the Allan key provided.
6) Ensure all stem valves are tightly closed.
7) Invert cell and place in filtration mounted heated jacket assembly. Rotate the bomb until it seats on the locking pin. Insert a thermometer into the HTHP cell.
8) Place a CO_2 or N_2 cartridge in each regulator and tighten up the retainers.
9) Place the pressure unit on top valve and lock into place using a locking pin. Lock the bottom pressure unit to the bottom valve into place, again ensuring that locking pin is inserted.
10) Apply 100 psi to both ends of the HTHP cell with the valves still closed.
11) Open the top valve by turning 1/4 to 1/2 anticlockwise to apply 100 psi to the mud while heating to prevent the mud from boiling prior to reaching the target temperature. The time for heating the mud sample to the target temperature should not exceed 60 minutes.
12) When the cell reaches the required test temperature open the bottom stem (1/2 turn) and then increase the pressure on the top regulator to 600 psi over +/- 20 seconds.
13) Commence the test. The test should be carried out as soon as the bomb reaches the test temperature.
14) If the pressure on the bottom regulator increases significantly above 100 psi bleed off some of the filtrate into the graduated cylinder.

15) Collect the filtrate for 30 minutes maintaining the temperature to within ± 5˚ F.
16) Once the test has finished close the top and bottom valves and shut off the pressure supply from the regulators. Bleed the lines using the relief valves provided.
17) Allow filtrate to cool for 30 minutes and then draw off into a graduated 20 ml measuring cylinder and read volume. SAVE the filtrate for ionic analysis.
18) CAUTION - the cell still contains 500 psi pressure, so cool cell to room temperature ideally in a water bath or alternative safe place and then bleeds off the pressure slowly by opening the valves.
19) Disassemble the cell and discard mud into mud waste container only. Save filter paper handling with care and wash filter cake with a gentle stream of distilled water.
20) Measure and report the thickness of the cake to the nearest 1/32” (0.8 mm). Report any other observations, such as texture, colour, hardness, flexibility etc.

3.2.5 Evaluation on the results obtained from several experiments

After analyzing all the data from the previous experiments, find the characteristics and properties in term of material, reaction, and principles of HTHP fluid loss reducer that creating the function of the HTHP fluid loss reducer. Then compare the performance of each sample and evaluate each sample in accordance to the objective required for the research.

3.3 GANTTCHART

FYP 1															
Activities	Week														
	1	2	3	4	5	6	7		8	9	10	11	12	13	14
FYP briefing															
FYP topic bidding and selection															
Preliminary research work															
Preliminary report submission															
Studies on drilling fluid and its content															
Studies on HTHP fluid loss reducer and oil-based mud properties															
Progress report submission															
Project defense and progress evaluation															
Studies on equipment and materials required															
Lab equipment familiarization															
Submission of interim draft report															
Submission of interim report															

FYP 2

Activities	Week														
	1	2	3	4	5	6	7		8	9	10	11	12	13	14
Project continues															
Visit to Scomi OilTools for consultant															
Project improvement															
Submission of progress report															
Results compilation and analysis															
Pre-SEDEX															
SEDEX															
Submission of draft report															
Submission of soft bound of dissertation															
Submission of technical paper															
Oral presentation															
Submission of project dissertation															

Figure 3: Ganttchart of FYP 1 and FYP 2

CHAPTER 4

RESULT AND DISCUSSION

In this experiment, the performance of this synthetic HTHP fluid loss reducer was observed by comparing mud properties in three different types of base oil which were *Sarapar 147, Saraline 185V,* and *Escaid 110.* This synthetic HTHP fluid loss reducer is *Confi-Trol XHT* that was supplied by SCOMI Oiltools. *Confi-Trol F* was used as the base case study to compare with the performance of new *Confi-Trol XHT.* Using the basic mud formulation 11.5lb/gal at 75/25 oil water ratio SBM formulation, the formulation for each base oil were determined by using this ingredient:

Base oil	Sarapar 145 / Saraline 185V / Escaid 110
Primary emulsifier	Confi-Mul P
Secondary emulsifier	Confi-Mul S
Viscosifier	Confi-Gel
Fluid loss reducer	Confi-Trol XHT / Confi-Trol F
Alkalinity source	Lime
Brine	Fresh water
	$CaCl_2$
Weighting agent	Drill Bar

Table 3: Elements in basic SBM formulation

Emulsifier, viscosifier, fluid loss reducer, and alkalinity source were made as constant elements to generate 11.5lb/gal at 75/25 oil water ratio SBM formulation for different type base oil. Quantities for these elements in mixing procedure for different type of base oil were the same, and using some calculation, quantities of base oil, brine and weighting agent can be determined.

PRODUCT	DESCRIPTION	QUANTITY (gram)
CONFI-MUL P	Primary emulsifier	3.00
CONFI-MUL S	Secondary emulsifier	9.00
CONFI-GEL	Viscosifier	8.50
CONFI-TROL XHT / CONFI-TROL F	Fluid loss control	8.00
LIME	Alkalinity source	8.00

Table 4: Constant elements in SBM formulation

Products	Sarapar 147	Saraline 185V	Escaid 110
Base oil	159.66	157.31	161.31
CONFI-MUL P	3.00	3.00	3.00
CONFI-MUL S	9.00	9.00	9.00
CONFI-GEL	8.50	8.50	8.50
CONFI-TROL XHT	8.00	8.00	8.00
LIME	8.00	8.00	8.00
Drillwater	67.37	67.23	67.47
$CaCl_2$	26.95	26.89	26.99
DRILL-BAR	192.71	195.26	190.92

Table 5: Formulation for Confi-Trol XHT for each base oil (value in gram)

Products	Sarapar 147	Saraline 185V	Escaid 110
Base oil	159.44	157.09	165.36
CONFI-MUL P	3.00	3.00	3.00
CONFI-MUL S	9.00	9.00	9.00
CONFI-GEL	8.50	8.50	8.50
CONFI-TROL F	8.00	8.00	8.00
LIME	8.00	8.00	8.00
Drillwater	67.28	67.13	67.63
$CaCl_2$	26.91	26.85	27.05
DRILL-BAR	193.06	195.61	186.65

Table 6: Formulation Confi-Trol F for each base oil (value in gram)

The mud rheology tests were conducted in two stages which were after the mixing process at 120°F, so called initial results, and after the mud been introduced in elevated high temperature and high pressure in hot rolling oven for some times, so called after ageing results. It was decided to set the pressure of 500psi and the temperature of 300°F for ageing process, for 16 hours to simulate for real applications of HTHP wells.

4.1 RESULT

The results of evaluation the performance of synthetic HTHP fluid loss reducer which was in this study was a *Confi-Trol XHT* in three different types of base oil which were *Sarapar 145, Saraline 185V,* and *Escaid 110,* consists of two main subjects, initial result right after mixing procedure, and after ageing result when the drilling mud formulation were introduced into hot roller [*see Appendix 2: figure 16*] that the temperature have been set to 300°F/149°C for 16 hours to simulate real well conditions.

4.1.1 Initial Properties:

Properties (Initial)	SPEC	Confi-Trol XHT			Confi-Trol F		
		Sarapar 147	Saraline 185V	Escaid 110	Sarapar 147	Saraline 185V	Escaid 110
Mud density, lb/gal		11.5	11.5	11.5	11.5	11.5	11.5
Rheological properties		120 °F	120 °F	120 °F	120 °F	120 °F	120 °F
600 RPM		118	214	218	120	123	146
300 RPM		77	146	152	88	89	107
200 RPM		61	118	126	63	66	75
100 RPM		45	85	91	51	53	58
6 RPM	>10@150	19	34	37	27	34	33
3 RPM		16	28	34	16	25	30
PV, cP		41	68	66	32	34	39
YP, lb/100 ft^2	15-20@ 120	36	78	86	56	55	68
Gel 10 sec, lb/100 ft^2		26	30	35	31	34	35
Gel 10 min, lb/100 ft^2		38	99	66	40	53	55
ES, volts at 120°F	> 400	819	1027	665	708	667	622

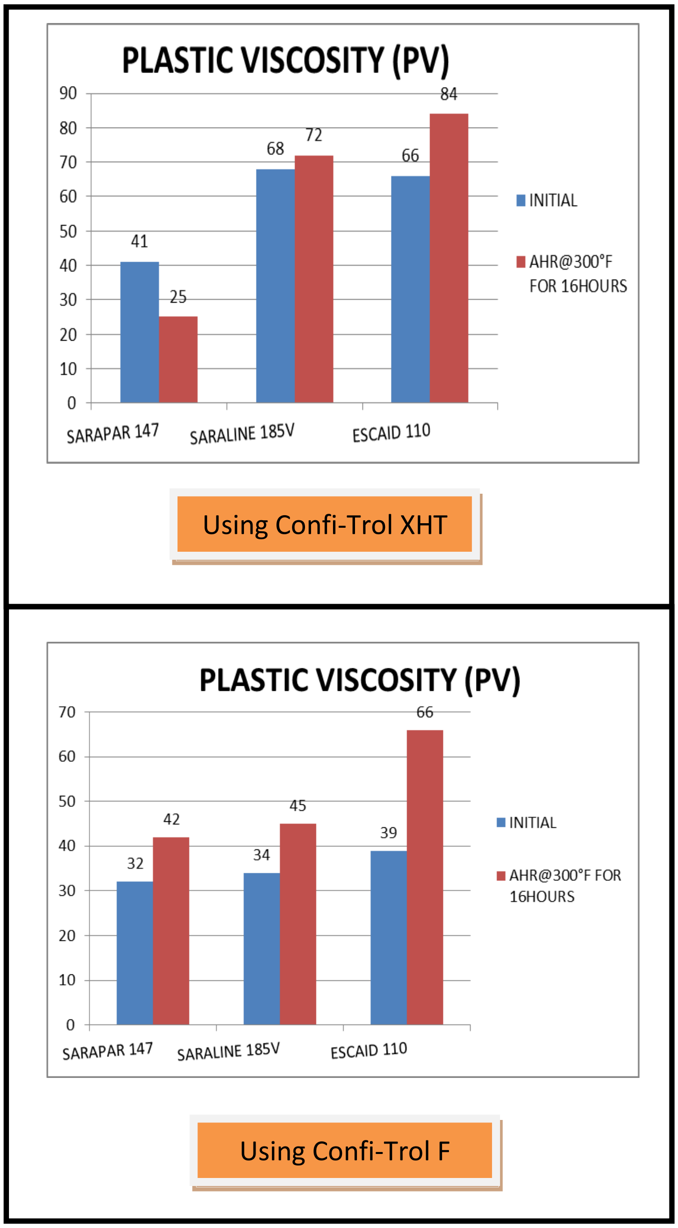
Table 7: Initial result after mixing procedure

4.1.2 After Ageing Properties:

AHR @ 150 C for 16h	SPEC	Confi-Trol XHT			Confi-Trol F		
		Sarapar 147	Saraline 185V	Escaid 110	Sarapar 147	Saraline 185V	Escaid 110
Mud density, lb/gal		11.5	11.5	11.5	11.5	11.5	11.5
Rheological properties		120 °F	120 °F	120 °F	120 °F	120 °F	120 °F
600 RPM		84	180	220	137	150	193
300 RPM		59	108	136	95	105	127
200 RPM		46	77	112	53	78	85
100 RPM		24	51	72	35	51	55
6 RPM	>10@150	18	32	10	20	36	37
3 RPM		15	15	6	14	21	13
PV, cP	<30	25	72	84	42	45	66
YP, lb/100 ft^2	15-25@ 120	34	36	52	53	60	61
Gel 10 sec, lb/100 ft^2	8-18	17	15	18	5	4	4
Gel 10 min, lb/100 ft^2	15-30	22	21	31	14	6	6
HTHP, cc/30min at 300F	<4	4	4	5	9	10	14
ES, volts at 120°F	> 400	952	641	481	410	385	354

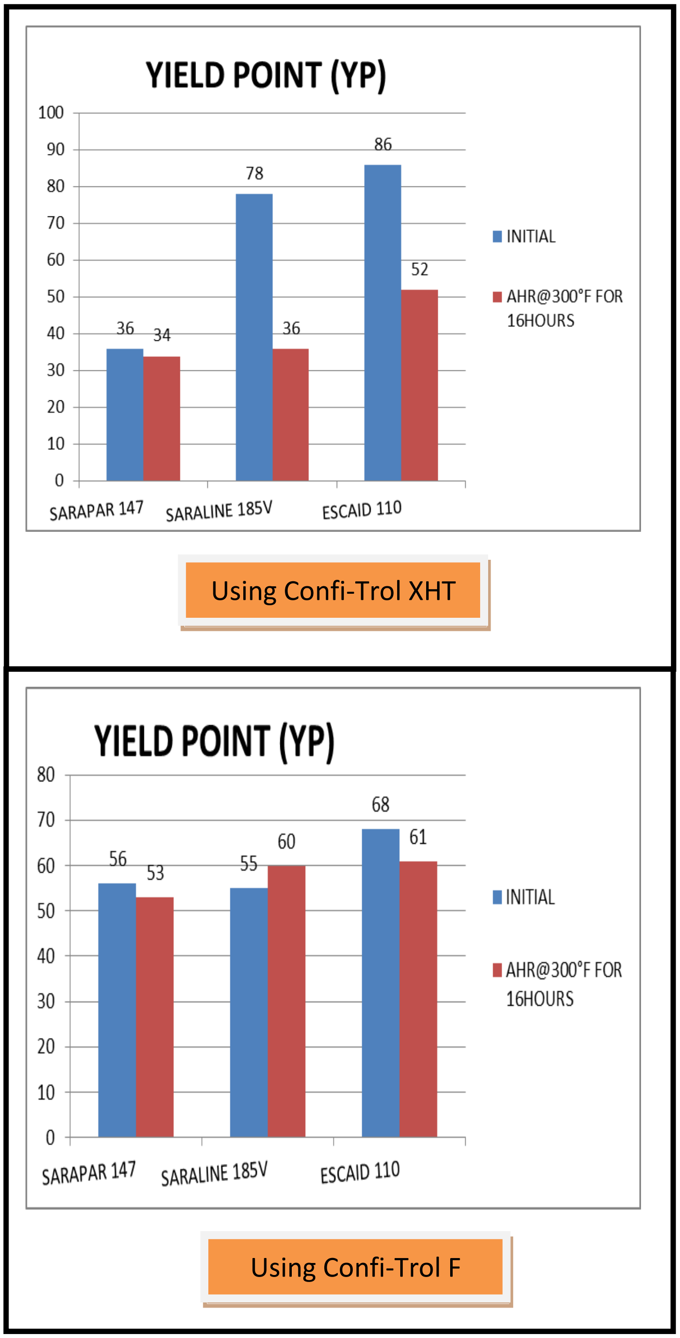
Table 8: After ageing result

4.1.3 Result Analysis:



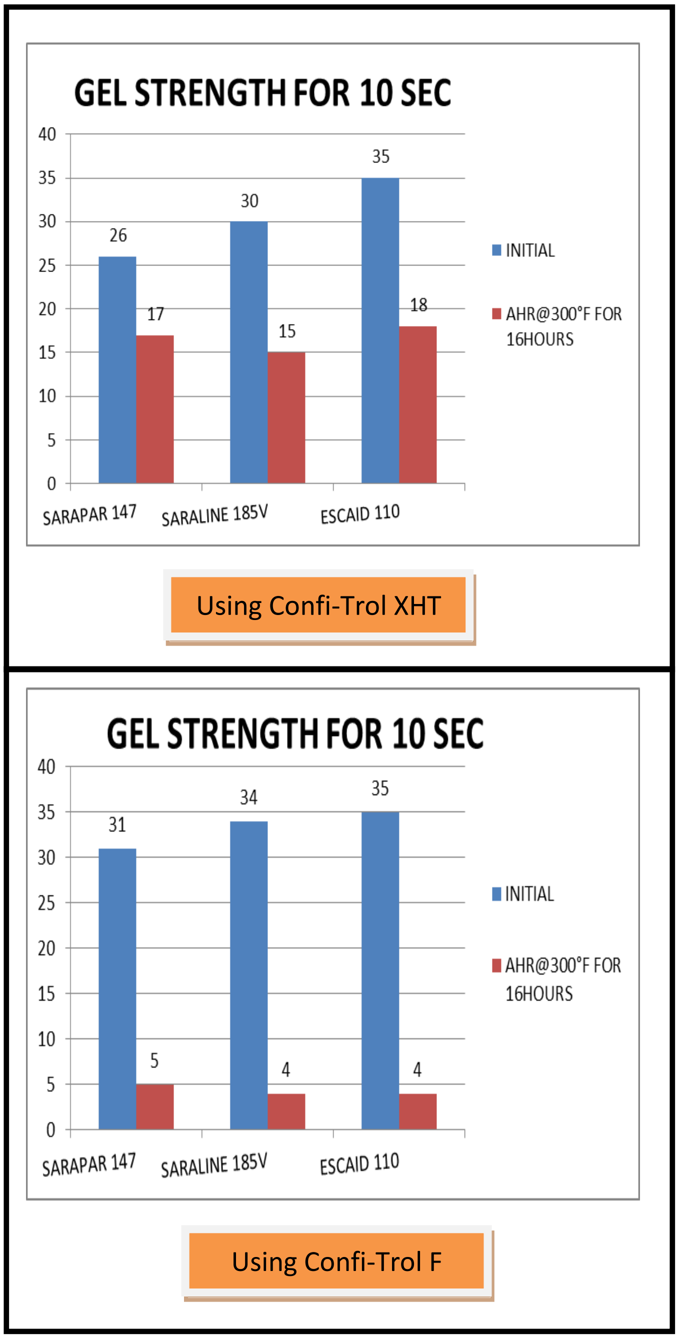
Plastic viscosity represents the viscosity of a mud. It indicates the amount of solid in the mud. A low plastic viscosity indicates that the mud is capable of drilling rapidly and high plastic viscosity is caused by a viscous base fluid and by excess colloidal solids. From the results, it shows that SARAPAR 145 have the lowest plastic viscosity compare to other base-oil. Comparing the performance between these two HTHP fluid loss reducers, averagely, CONFI-TROL F seems having good plastic viscosity than CONFI-TROL XHT.

Figure 4: Comparison of Plastic Viscosity



Yield point indicates the ability of mud to suspend and lift cutting out from the annulus. For HTHP conditions, yield point specification to be reach for mud to work best is in range 15-35. It shows that SARAPAR 145 with CONFI-TROL XHT best suited for HTHP wells in lifting the cuttings while the others are out of specification.

Figure 5: Comparison of Yield Point



The gel strength or shear strength of a drilling mud determines its ability to hold solids in suspension and retain its gel form. In this study, barite was used as colloidal clay. CONFI-GEL XHT also being used as organophilic hectorite clay, to give the gel strength and also as viscosifier. In this case, SARAPAR 145 with CONFI-TROL XHT meets the specifications which are for 10 seconds gel strength , the range are 8-18 lb/100 ft^2 and for 10 minutes gel strength, the range are 15-30 lb/100 ft^2 . It shows that CONFI-TROL F could not withstand 300°F as the differences between initial reading and after hot roll were too high.

Figure 6: Comparison of Gel Strength for 10 seconds

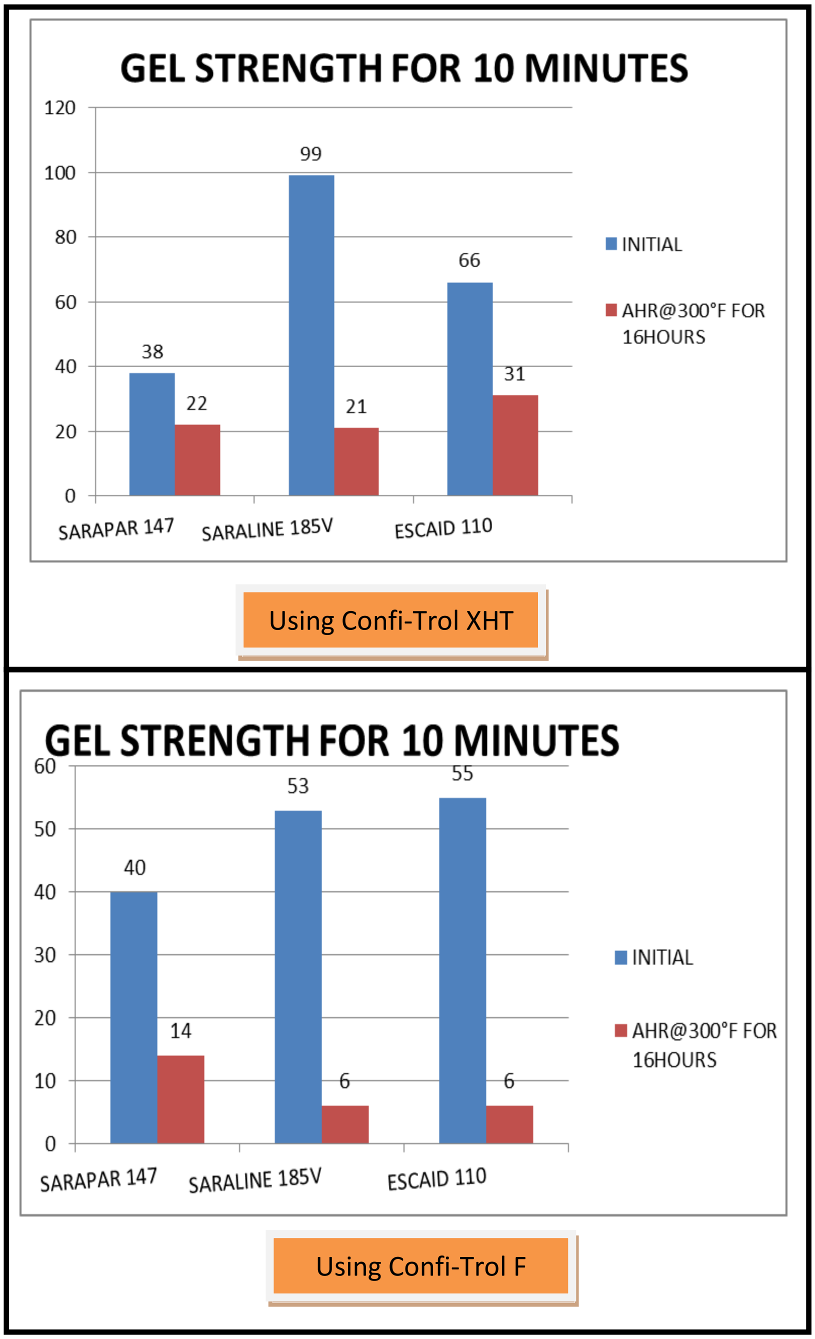
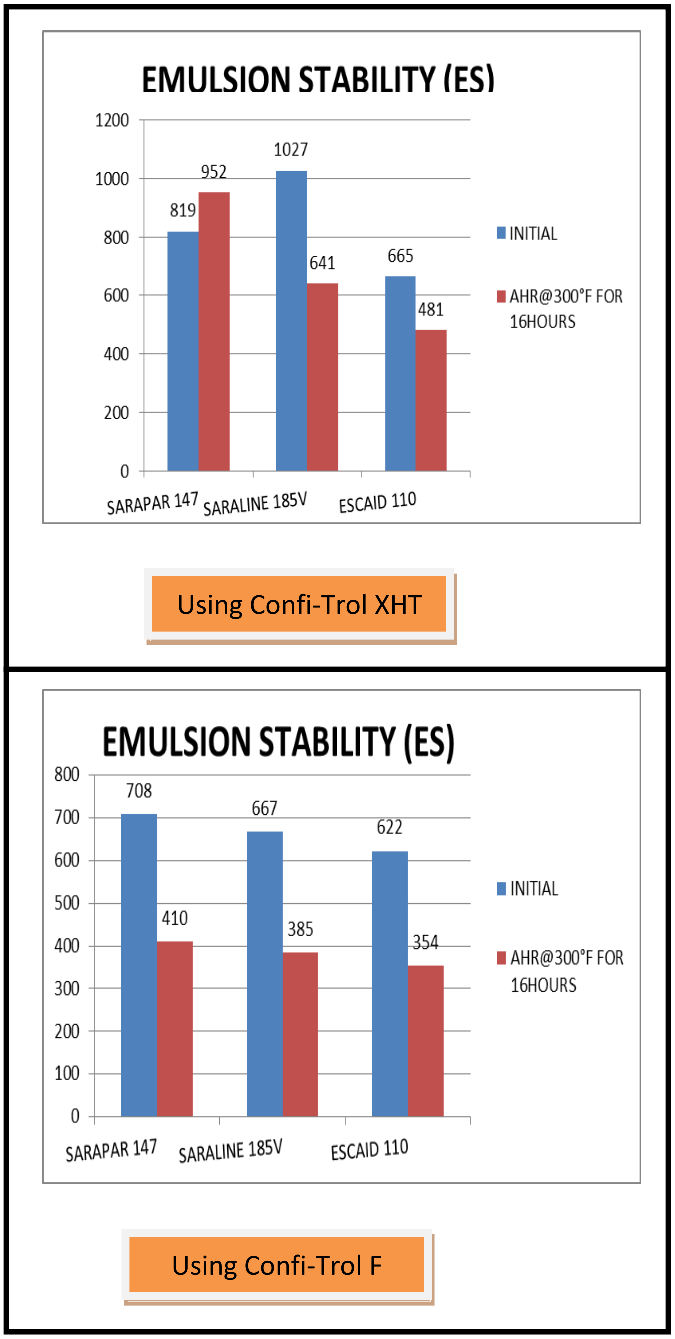
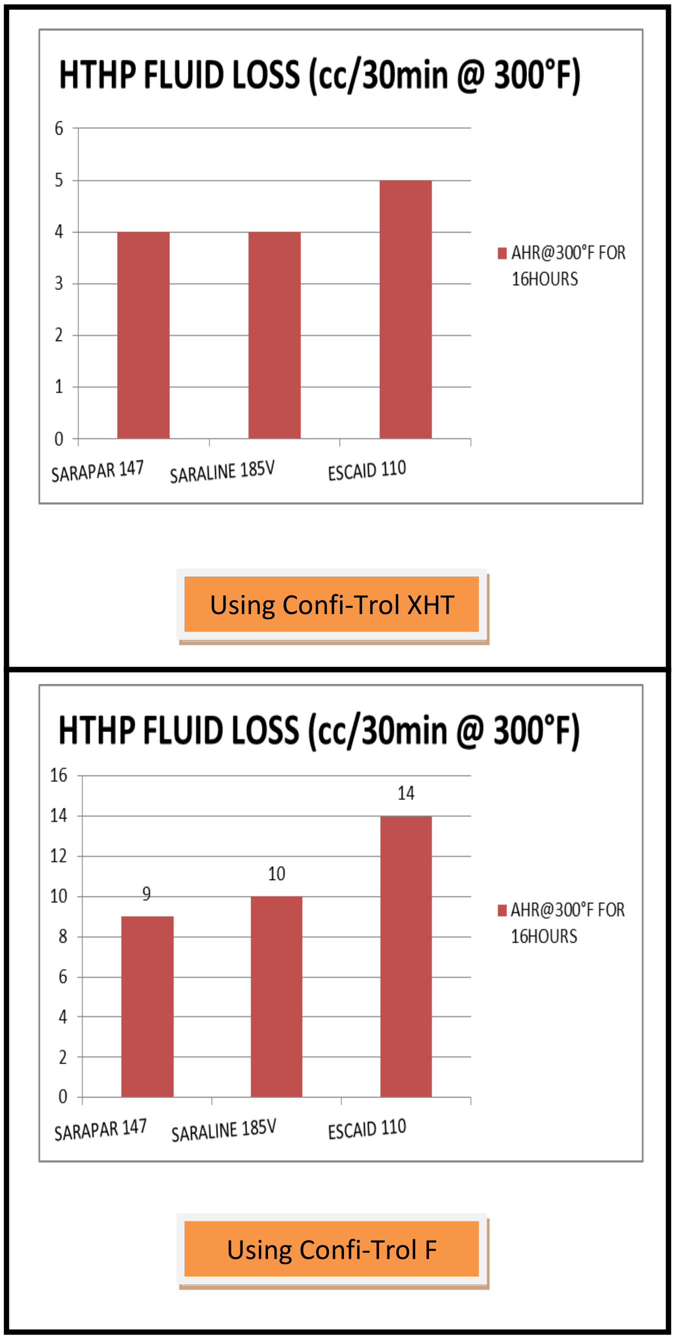


Figure 7: Comparison of Gel Strength for 10 minutes



The higher the emulsion stability value, the better is the mud. Using the CONFI-TROL XHT, SARAPAR 145 shows promising result as the emulsion stability getting higher after hot rolling process. Applying for real cases that SARAPAR 145 have stabilize emulsion in HTHP wells. Comparing mud properties using CONFI-TROL XHT with mud using CONFI-TROL F, it is obvious that using CONFI-TROL XHT much more stabilize for wells that up to 300 °F.

Figure 8: Comparison of Emulsion Stability



HTHP fluid loss test is designed to measure the mud ability to prevent fluid loss during the circulation in the high temperature and high pressure wells. Mud will considered as good mud if minimal fluid loss into the formation. The results shows that the less fluid loss were SARAPAR 145 and SARALINE 185V, both mixed with CONFI-TROL XHT. Meanwhile for CONFI-TROL F, it seems the rate is unacceptable for HTHP wells.

Figure 9: Comparison of HTHP Fluid Loss

4.2 DISCUSSION

Confi-Trol XHT is a Scomi Oiltools' product that functioned as filtration and suspension control in HTHP systems. It is a unique gel resin designed for use in oil and synthetic based muds. The particle morphology, the resin solubility and the crosslink density have been optimized for the fluid-loss additive can withstand in particular for high temperature and high pressure applications. This study mainly to compare the performance this product in the application of different base oil consists of *Sarapar 145, Saraline 185V,* and *Escaid 110.*

Based on the result analyses that have been made, it shows that *Sarapar 145* is the most compatible base oil with *Confi-Trol XHT.* The formulation with *Sarapar 145* gives better result in term of PV, YP, Gel Strength, ES and HTHP Fluid Loss Test after ageing process compare to the *Saraline 185V,* and *Escaid 110.* Performance after ageing process indicates the ability of the formulation to withstand in HTHP well conditions that have been set up to 300°F and 500psi in laboratory testing, simulated for the standard HTHP well condition.

Sarapar 145 has the lowest rate of HTHP Fluid Loss, followed by *Saraline 185V,* and *Escaid 110,* proves that *Sarapar 145* formulation with *Confi-Trol XHT* gives greater ability in fluid loss control. It means that even after being introduced on HTHP wells, *Sarapar 145* can reduces the fluid loss to the formation and slowing the mud cake formation, increasing the chances for the drilling mud to circulate better in the wells without having problems of immature mud cake formation in the wells that can cause drilling pipe stuck or any problems regarding of this matter.

In any drilling mud formulation, mud rheology need meet requirement of industry standard specification that being used by most company in oil and gas industry. Thus, in accordance this specification, if mud formulation meets the range of these specifications, it will be considered as good mud and ready to be used in real time applications.

Fluid Properties	Specification
Mud density, SG	1.2
6 rpm dial reding	8-16
Yield point, lb/100ft^2	15-35
10 sec gel strength, lb/100ft^2	8-18
10 min gel strength, lb/100ft^2	15-30
HTHP @ 300°F, 500 psi, ml/30min	<4
Electrical stability, volt	>400

Table 9: Industry Standard Specification after Ageing Process

The result was taken by comparing with other fluid loss control that already had been establish to evaluate its performance such as *Confi-Trol*, and *Confi-Trol F*. *Confi-Trol* is a gilsonite act as a fluid loss control that been used in normal well conditions, and *Confi-Trol F* is an liquid fluid loss for high temperature additive that mostly used nowadays in HTHP wells. Using these two types of fluid loss control, the performance measure to evaluate whether *Confi-Trol XHT* is better performance compare to the existing one.

Rather than act alone in becoming the only HTHP additive, using HTHP viscosifier can help improve its performance. Still it needs to be done pre well testing whether it is compatible or not. The HTHP viscosifier that can be added in the experimental list is a *Confi-Gel HT*, so the trend of the performance can be shown more clearly and give enough information for drilling mud to choose in future.

In this research, the primary emulsifier that has been used was *Confi-Mul P* and the secondary emulsifier was *Confi-Mul S*. Both were combinations to best suited in HTHP conditions. Using secondary emulsifier is necessary in drilling mud to act as a supplement, anionic emulsifier for base-oil fluids and also to enhance primary emulsifier in paraffin carrier fluid.

The improvement can be made by formulating new formulation of this SBM by manipulating its concentration, thus, set a new value of its constant elements to achieve industry specification. *Confi-Trol XHT* is used at low concentrations of 0.5 – 6 lb/bbl (1.4 – 17.1 kg/m^3), hence by using new formulation that generate mud at this range of concentration, the result will be better than what were obtained from this research.

The emulsion stability also should be higher than what was obtained in this research compromising by the factor of emulsion producing date. This emulsifier was the old emulsifier, so it was not quite effective. In future, to get better results, this factor need be considered.

CHAPTER 5

CONCLUSION

Nowadays, deep water wells have been explored due to its high production rate. Unfortunately, the risks also will be higher rather than shallow water wells. In most cases, drilling fluids that will be used in drilling extremely hot wells is oil based mud. Today, we already have new invention on oil base drilling fluids to overcome environment issue which is synthetic oil base. Eventually, there still no data regarding the differences between this synthetic oil base which have various types of it. Form this research, information on comparison based on the performance of the synthetic oil base in term of rheology properties and behaviors in high temperature can help many applications in HTHP wells to prevent problems occur. Also from this research, it can lead the innovation of new formulating HTHP fluid loss reducer.

From the result obtained, it is shown that *Confi-Trol XHT* has better performance than *Confi-Trol F* for HTHP wells application. In the elevated high temperature that have been set up to 300°F and high pressure up to 500 psi, shown that *Confi-Trol F* cannot withstand up to this conditions even though it is HTHP fluid loss reducer. Improvements have been made to this new products and it was proven that it is a successful products.

In conclusion, *Confi-Trol XHT* has better performance than *Confi-Trol F* in HTHP conditions and is best suited using the *Sarapar 145* as base-oil for better impact.

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APPENDICES

APPENDIX 1

Figure 10: Mixer

Figure 11: Baroid Mud Balance

Figure 12: Marsh Funnel Viscometer

Figure 13: FANN 35A Viscometer

APPENDIX 2

Figure 14: FANN 75A Viscometer

Figure 15: Standard API Filter Press

Figure 16: HTHP Filter Press

Figure 17: Hot Roller Oven

APPENDIX 3

Figure 18: Electric Stability kit