Petroleum & Coal
ISSN 1337-7027
Available online at www.vurup.sk/pc
Petroleum & Coal 53 (2) 140-145, 2011

EXPERIMENTAL STUDY OF THE EFFECT OF TEMPERATURE ON THE FLOW PROPERTIES OF NORMAL OIL BASED MUDS IN NIGER DELTA FORMATION

Olufemi A. Adekomaya [1], Dolapo M. Anifowose [1], Talabi Wale[2]

[1]*University of Lagos, Department of Petroleum and Gas Engineering,Akoka, Lagos,Nigeria.*
[2] *Mi – Swaco Drilling Company, Portharcourt, Nigeria.*

Received November 9, 2010, Accepted April 15, 2011

Abstract

The behaviour of the drilling fluids under high temperature is extremely important for drilling deep wells. Most commercial oil base drilling fluid systems have limitations such as reduced rheology and filtration control if the fluid is exposed to higher temperature for prolonged periods of time. Formulating a drilling fluid system that can adequately withstand drilling in a high temperature environment is very challenging but very often little attention is given to proper fluids design. In this research, a normal oil based mud suitable for Nigerian formation was formulated and was aged under high temperature conditions for 16 hours. The effect of aging on the properties of drilling fluids was studied. From the study, it is concluded that rheological changes in drilling fluids have many effects on the degree of efficiency with which a fluid performs its primary functions and it is important that efforts are made to minimize these detrimental effects.

Keywords: drilling mud; viscosity; gel strength; fluid loss; yield point.

1. Introduction

Oil based drilling fluids, also referred to as oil based mud(OBM) are complex fluids which typically may consist of ten different components. In most cases OBM are invert emulsions with oil as the continuous phase. The aqueous phase of emulsions is often droplets of brines stabilised by emulsifiers and added lime for alkalinity. Weight materials are added to control the density of the fluids, while wetting agents may be added to increase the oil wetting of weight materials and other solids. Viscosifiers are added to increase the viscosity and fluid loss materials are added to reduce the flow of fluids from OBM into formations while drilling. Drilling fluids have three main functions:(1) To transport drill cuttings out of the hole and to allow for separation of cuttings from the drilling fluids at the surface.(2) To form a thin filter cake on the walls of the wellbore to prevent inflow of drilling fluids into the formations.(3) To prevent inflow of formation fluids into the wellbore [4].It is now a well estabilished fact that the success of a drilling operation relies to a large extent on the physical /rheological properties of the drilling fluid used for lubricating drill bits. In fact, in most drilling operations, controlling the viscosity, gel strength, yield point, and filtrate loss of the drilling fluids within a given range have been realised to be vitally important. To impart desired properties to a typical drilling fluid, it is often necessary to use several additives either separately or concurrently. The major drawback of these conventional additives is that they are generally unstable at high temperatures normally encountered in deep wells. Early investigations into the effect of temperature on the flow properties of drilling fluid were performed by Barlett [1] .The study showed significant decrease in viscosity(by half) of a particular ligno-sulfonate mud when its temperature was increased from 80^0F to140^0F. Combs and Whitemire [2] showed that the change in viscosity of the continuous phase is the main factor in control the change in the viscosity of the mud with pressure. De Wolfe et al. [3] reported a close correlation of the results from their study of less toxic oils to the Herschel-Bulkley model. It was also observed that the magnitude of viscosity difference between oils tend to decrease with temperature in spite of pressure indicating that temperature was the more dominant factor. In the present work, the rheological and electrical properties of Nigerian oil based mud are investigated under a high temperature conditions in order to know the extent at which temperature begins to impair the efficiency of the mud.

2 Methodology

This experimental work is carried out at MI-SWACO Portharcourt, Nigeria. The process started by formulating the four mud samples and was aged under high temperature conditions for 16 hours so as to study the effect of aging on the properties of drilling muds.

2.1 Experimental procedures

The Oil base mud consists of diesel oil and water at a ratio of 75/25.The base drilling fluid used is EDC 99 and the composition of the mud consists of $CaCl_{2,}$versagel plus, lime, versacoat, versamul, versatrol, water and barite. Versagel plus acts as a viscosifier while versamul and versacoat acts as primary and secondary emulsifiers. Versatrol which is one of the compositions acts as a fluid loss controller. Four mud formulations were chosen based on rheological and filtration properties for use in Nigerian deep wells using all the materials in the above formulation and were aged at temperatures between 150^0F-350^0F for 16 hours. The muds are mixed according to the procedures recommended by API and other related mud service companies. Mud mixer is used to mix the four muds so as to ensure a homogeneous mixture. The mixer is set on different speeds of 600rpm, 300rpm, 200rpm, 100rpm, 6rpm and 3rpm at the temperature of 120^0F.The viscosities of each of these samples are taken and recorded. A rotational V.G viscometer is used to measure the rheological properties of mud samples. This viscometer has 6 speeds (600rpm, 300rpm, 200rpm, 100rpm, 6rpm and 3rpm) as recommended by API to measure the rheological properties of drilling mud samples. The properties are measured at 120^0F and aged temperatures between 150^0F-350^0F. The rotational viscometer is also used to measure the gel strength which is classified into 10 seconds gel strength and10 minutes gel strength. The 10secs gel strength reading is taken at 3rpm after 10sec while the 10mins gel strength reading is taken at 3rpm after 10minutes. The maximum deflection of the indicator is recorded. For measuring the fluid loss of the mud samples, HT-HP Filter Press is used. The drilling fluids are heated to a temperature of 250^0F at a pressure of 500psi.The filtrate test is run for 30 mins upon which the volume of filtrate is recorded and the filter cake thickness is measured and reported. It is made air tight by applying a HT-HP grease to the oil ring.

In all these experiments, conditions are kept constant for mixing and testing to have a representative comparison for the four formulated muds.

3. Results and discussion

Fig 1 summarizes the experimental results showing the measured viscosity of the mud samples before and after aging. Aging process was used to mimic the downhole condition. The results indicate that regardless of aging, all samples show significant difference in viscosity value .For instance, the versaclean mud at 120^0F gives a set of values which increase with increasing speed. However, after aging, the Versaclean mud follows the same trend. In addition, it is also observed that an increase in speeds during mixing also changes the values of the measured viscosity. Also as the aging temperature of the Versaclean mud increases, there is decrease in viscosity. For a Niger Delta formation with unpredictable bottomhole conditions, a high viscosity is desirable to carry cuttings to surface and suspend weighting agents in the mud. However, if the viscosity is too high, friction may impede circulation of the mud causing excessive pump pressure, decrease the drilling rate and hamper the solids removal equipment.

Fig 2, 3 and 4 show that as temperature increases the apparent viscosity, plastic viscosity and yield point decrease proportionally. Whereas at aging temperatures of 170^0F,210^0F and 150^0F the rheological parameters of the suspensions, containing apparent viscosity, plastic viscosity and yield point decrease significantly. This indicates that exposure to high temperatures for long hours make the barite dispersed and lose properties needed as a high temperature drilling fluid, which renders it ineffective and requires additional treatment. As a matter of fact, this mud properties can only achieve its functions in a Nigerian formation whose temperature is below 150^{0}F.

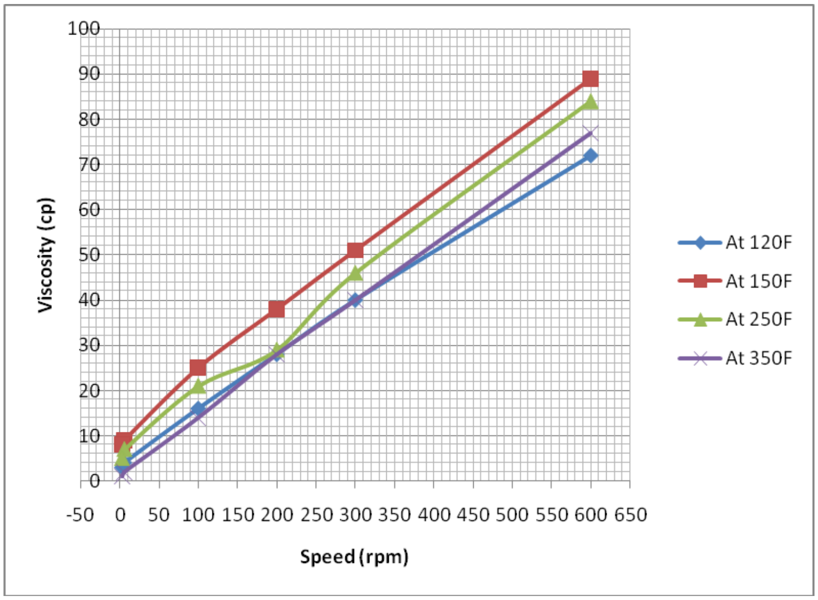

Fig. 1 Effect of aging on mud speed of Versaclean mud

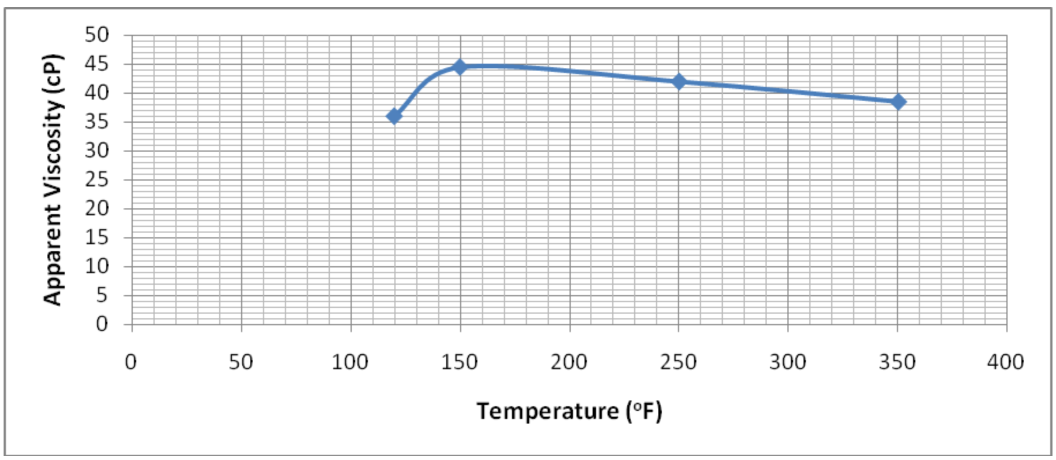

Fig.2 Effect of aging on apparent viscosity of Veraclean mud

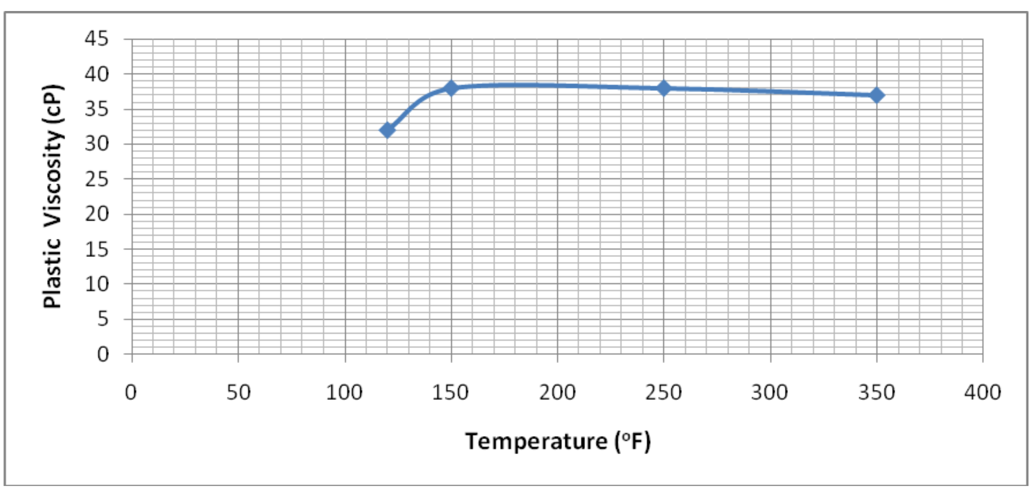

Fig.3 Effect of aging on plastic viscosity of Versaclean mud

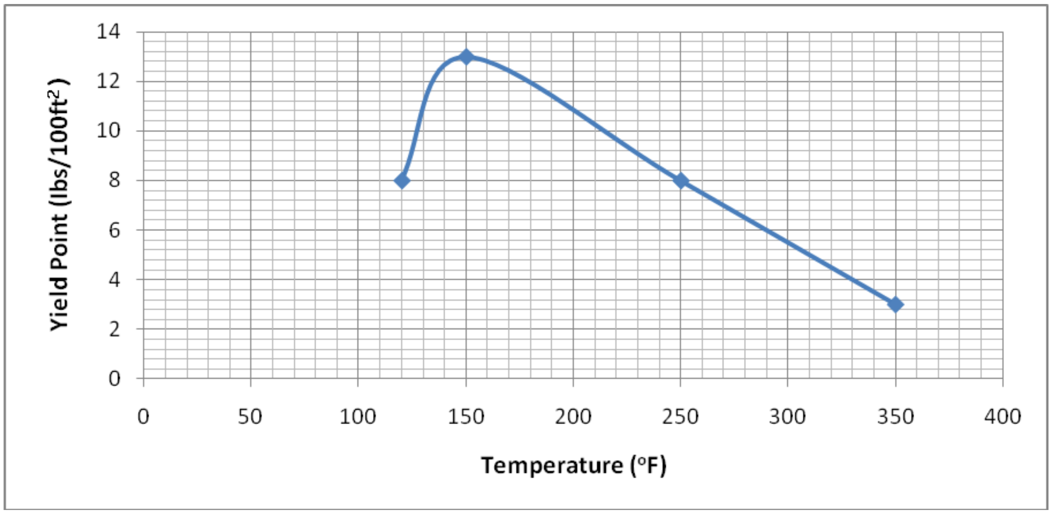

Fig. 4 Effect of aging on yield point of Versaclean mud

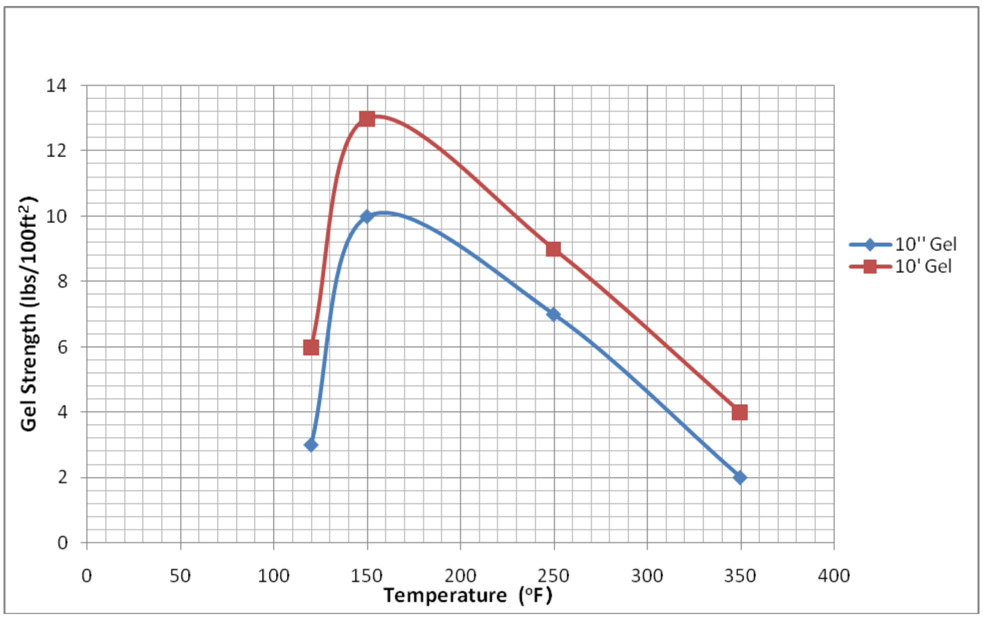

Fig. 5 Effect of aging on gel strength of Versaclean mud

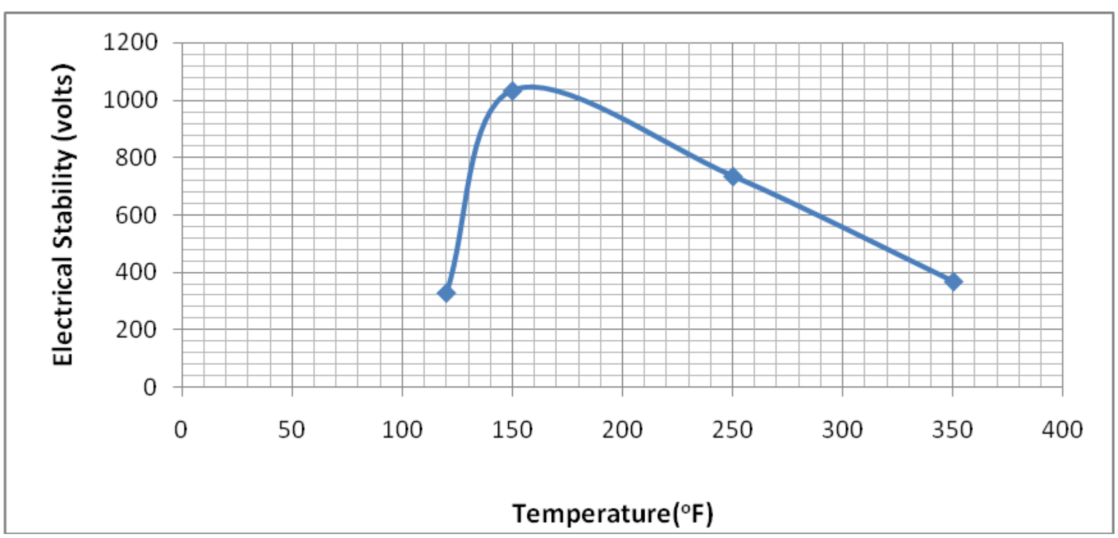

Fig. 6 Effect of aging on electrical stability of Versaclean mud

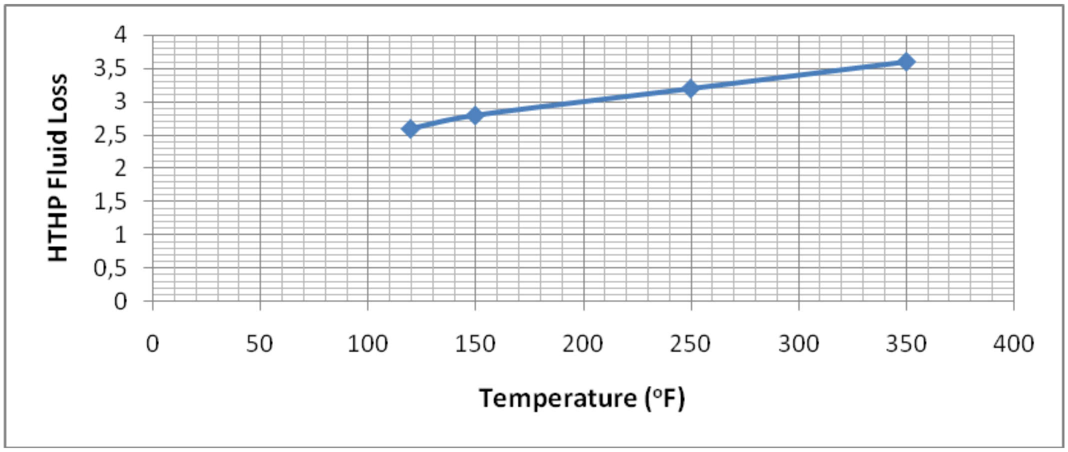

Fig. 7 Effect of aging on fluid loss of Versaclean mud

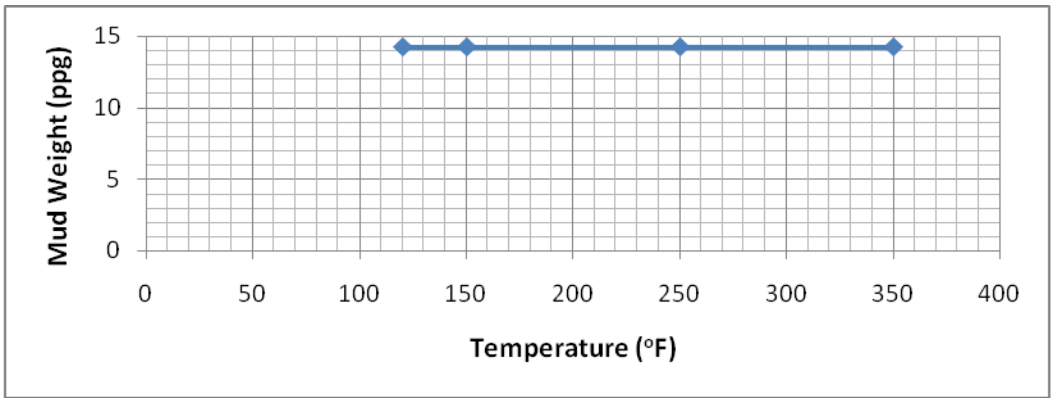

Fig. 8 Effect of aging on mud weight of Versaclean mud

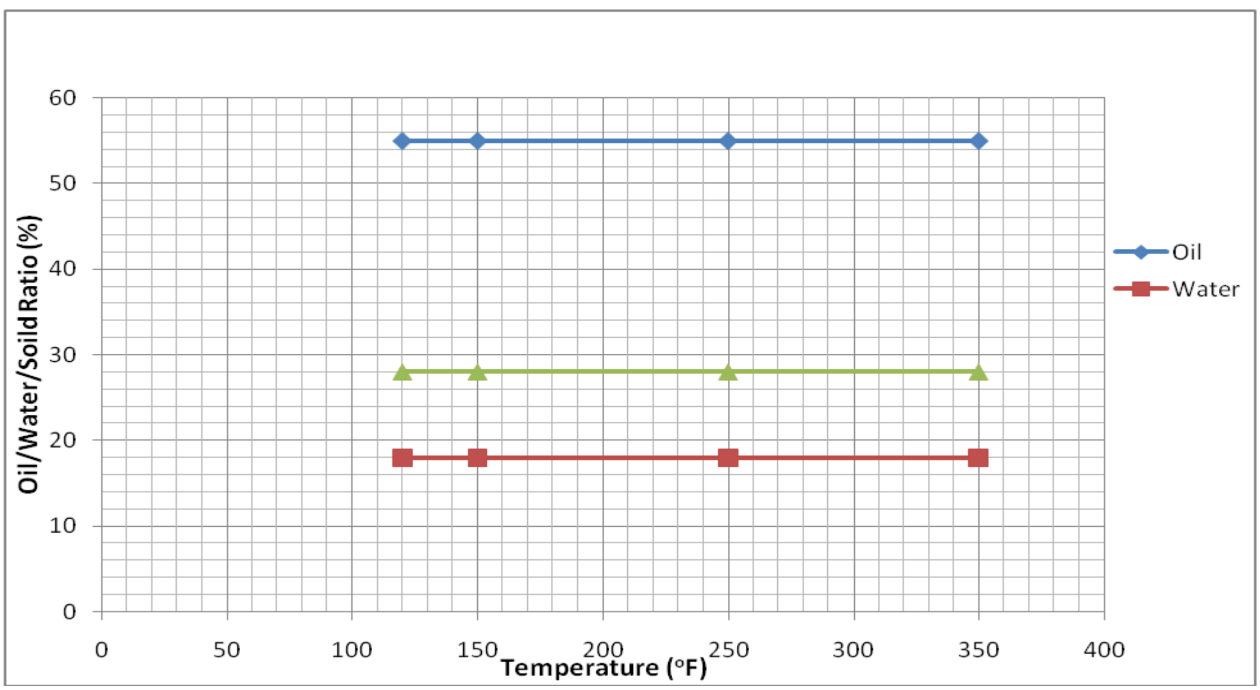

Fig. 9 Effect of aging on oil/water/solid ratio of Versaclean mud

It can be deduced from Fig 5 that as aging temperature increases, the 10 secs gel strength and 10 mins gel strength decrease simultaneously. It means that the longer the stagnation time, the harder the internal structures and more pressure will be required to initiate the flow of the fluid.

From fig 6, the electrical stability was plotted against temperature. At aging temperatures of 150^0F, 250^0F and 350^0F, ES gives a high value of 1034v, 735v and 368v. A close look at the results show that as aging temperature increases, the ES values decrease which indicates lower emulsifying strength, the electrical stability is an indication of how well (or tightly) the water is emulsified in oil or synthetic phase, higher values indicate a stronger emulsion and more stable fluid. A mud with an electrical stability of 1034v above is quite strong and good. In a Niger Delta formation, many high temperature wells requiring high mud weight have been drilled with muds measuring only 700-900volts,some even less, with no problems. An ES of 400volts or less is considered low. Therefore; this mud property should be restricted to formation temperature less than 240^0F.

Fig 7 shows Fluid loss plotted against Temperatures and it can be deduced that at a bottomhole temperature of 350^0F, there is a high leakage of the liquid phase of drilling fluid into the formation matrix. This mud property must be avoided in Nigerian formation of extreme bottom hole temperature.

Fig 8 and 9 show the effect of temperature on Mud Weight and oil/water/solid content. It can be deduced from the graphs above that temperature has no effect on mud weight as well as oil/water/solid content. For a Niger Delta formation drilled up to a high temperature of 350^0F the conditions of the mud weight and oil/water/solid content at any stage withing the formation remain the same.

4. Conclusions

1. It is concluded that barite does not have the tendency to perform adequately well under a high temperature for a long hours.
2. It is concluded that temperature has a great influence on ES value; as a result, temperature above 240^0F must be avoided.
3. Extreme bottomhole temperature must be avoided as this may lead to a high leakage of the liquid phase of drilling fluid into the formation matrix.

Acknowledgement

We wish to appreciate all the staff of MI-SWACO, Portharcourt Nigeria for their technical support during the experimental work of this research.

Nomenclature

OBM	Oil based mud
API	American Petroleum Institute
HT-HP	High temperature High pressure
ES	Electrical stability

References

[1] Barlett, L.E: Effects of Temperature on the Flow Properties of Drilling Fluids, Paper SPE 1861 presented at the (1967) SPE Annual Meeting of AIME,Houston,Texas 1-4 October.

[2] Combs, G.D and Whitemire, L.D.: Capillary Viscometer Simulates Bottom-Hole Conditions, Oil and Gas Journal (September 1968) 108-113.

[3] De Wolf, R.C., Coffin, G.B and Byrd R.V.:Effects of Temperature and Pressure on Rheology of less Toxic Oil Muds, Paper SPE11892 presented at the (1983) offshore Europe Conference,Aberdeen,6-9 September.

[4] Eldar Dingsøyr et al.: Oil Based Drilling Fluids with Tailor-Made Rheological Properties: Results from a Multivariate Analysis, Annual Transactions of the Nordic Rheology Society Vol 12, 2004.