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Development Mechanism of Drilling Fluid from Biomaterials

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ABSTRACT: Drilling fluids serve many objectives in a drilling process, including the elimination of cuttings, lubricating and cooling the drill bits, supporting the stability of the hole and preventing the inflow-outflow of fluids between borehole and the formation. However, with increasing production from non-conventional reservoirs, the stability and effectiveness of traditional drilling fluids under high temperature and high pressure (HTHP) environment have become big concerns. Both water and oil based drilling fluids are likely to experience a number of deteriorations such as gelation, degradation of weighting materials and breakdown of polymeric additives under HTHP conditions. Recently, nanotechnology has shown a lot of promise in the oil and gas sectors, including nanoparticle-based drilling fluids. This paper aims to explore and assess the influence of various nanoparticles on the performance of drilling fluids to make the drilling operation smooth, cost effective and efficient. In order to achieve this aim, the article will begin by explaining the important role that drilling fluid plays during the drilling process with a historical review of drilling fluid industry development. Then, definitions, uses and types of drilling fluid will be demonstrated as well as, the additives that are appended in order to enhance drilling fluid performance. Moreover, the maturation of the oil production industry from unconventional wells will be discussed after which the limitations and degradation of the traditional drilling fluid will be cleared up. Finally, this essay will discuss the great potential of nanotechnology in solving drilling problems in addition to the technical and the economic benefits of using nanomaterials in drilling fluids before offering a brief conclusion.

KEYWORDS: Drilling Fluids, Reservoir, Nanotechnology, HTHP Conditions, Nanoparticles, Nano-Fluid

1. INTRODUCTION

Every rotary drilling operation has three systems that work at the same time in boring hole: a rotating system which rotates the drill bit, a lifting system that raises and lowers the drill string into the hole, and a circulating system which performs the function of moving a fluid around from the drill stem, out of the drill bit and up again to the hole at the surface, this fluid is called drilling fluid. Drilling fluids are necessary for drilling success as they increase oil recovery and minimize the amount of time needed to achieve first oil. The drilling fluids in the drilling process can be considered the same as the blood in the human physical structure. The mud pump is the heart; the cuttings that are transferred from the borehole by drilling fluid represent the unwanted materials that are removed from the body by blood and the mud cleaning system works as the kidney and lungs. Recent investigations have demonstrated that nano-fluids have engaging features for applications where heat transfer, gel formation, drag reduction, binding ability for sand consolidation, wettability alteration, and corrosive control is of interest. Nano-fluids can be produced by adding nano-sized particles in low volumetric fractions to a fluid. The nanoparticles promote the fluid's rheological, mechanical, optical, and thermal characteristics. Fluids with nano-sized particles may provide the following supports:

- (1) Nano-sized particles can have enhanced stability against sedimentation since surface forces easily balance the gravity force.
- (2) Thermal, rheological, optical, electrical, mechanical and magnetic properties of nanoparticles, which depend significantly on size and shape, can be designed during manufacture and are often superior to the base material.

1.1 Background

Drilling operations are conducted to obtain oil and gas from natural reservoirs deep underground. To facilitate the extraction of hydrocarbons from the ground, a deep hole is drilled to form a wellbore. The use of drilling fluids is an important factor in the drilling process, and these fluids play many roles, such as to assist in removal of drill cuttings and



formation pressure control. There are viable chemical additives used in the drilling fluid that have shown the desired features. However, these additives are non-biodegradable and environmentally hazardous. As a result, researchers have sought to identify alternate additives that are environmentally friendly, biodegradable, and sustainable, while also maintaining the properties of efficient drilling fluids.

1. 2. Drilling Fluids and Rheological Properties

The principal functions of drilling fluids include removal of drill cuttings and cleaning of the wellbore, lubricating and cooling the drill bit and string, maintaining wellbore formation, and preventing well blowout. Thus, the drilling fluid plays a significant role in the upstream oil and gas industry. As a major success factor of drilling processes, the properties of drilling fluids are constantly monitored and adjusted as recommended by the American Petroleum Institute (API) Recommended Practice 13B-1 for WDF and Recommended Practice 13B-2 for ODF. Based on API Recommended Practice 13B-1, the International Organization for Standardization (ISO) has prepared and outlined the ISO 101,414 under the general title of Petroleum and Natural Gas Industries Field Testing

1.3 Waste Derivatives in Drilling Fluids

1.3.1 Emergence of Waste Materials in the Environment

The global population, which is currently 7.8 billion and growing at 1.1% per year, relies on the consumption of the Earth’s natural resources. Waste materials are unusable materials that have exceeded their use and been discarded. Unfortunately, an effect of this continued consumption is the proliferation in waste materials of all varieties, as shown in Figure 1.1

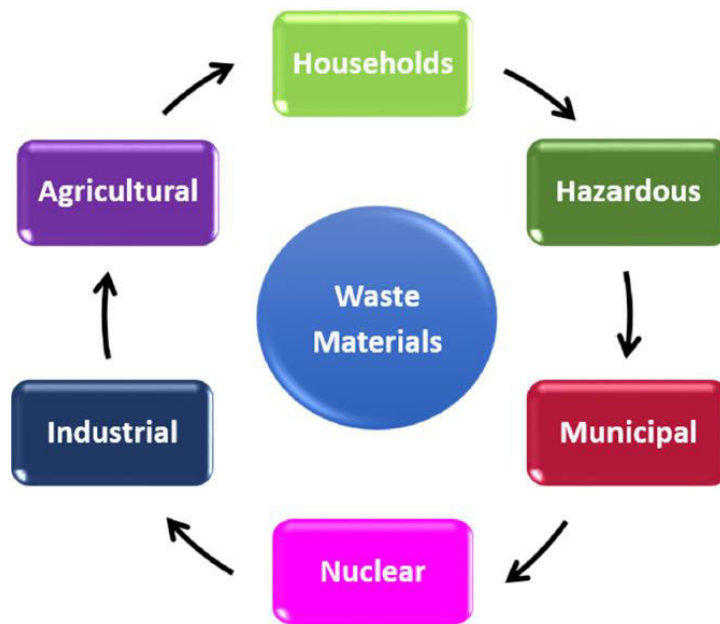


Figure 1.1. Production of various types of waste.

Waste material includes municipal solid waste (MSW), which comprises common items consumed and discarded by the public, and represents the fastest growing form of waste due to its prevalence in urban society. In a review of solid waste management, Hoornweg and Bhada-Tata estimated that, by 2025, MSW will increase to around 1.42 kg/capita/day (2.2 billion tonnes per year), generated by 4.3 billion urban residents. The authors also estimated that 1.8 million tonnes of MSW would be generated daily. Other types of waste are produced by a range of sources, including domestic and commercial; ash; animals; biomedical and construction industries; and sewers. These wastes may comprise industrial solid waste, biodegradable and non-biodegradable waste, and hazardous waste. Some of these types of waste pose a serious threat to the environment and human health. Clinical waste, which is produced by medical clinics, hospitals, and laboratories, carries the risk of infection and may spread disease if not appropriately managed. Electrical and electronic waste (E-waste), from electronic equipment such as cables, wires, cords, and batteries, releases dangerous substances, and thus causes serious harm to those who contact it, particularly workers in the recycling industry. Additionally, waste management requires recycling of hazardous waste by various approaches, as presented in Figure 1.2.



Figure 1.2. Strategies for recycling of waste materials.

Food waste is a major global issue that is caused by factors including poor food processing operations and management, inadequate household planning of food consumption, and over preparation of food in the food and beverage industry. Nevertheless, the problem of food wastage may be meaningfully addressed if the waste can be utilized and reapplied to different applications. The accumulation of wasted food in landfills results in the formation of methane gas and further pollution of the air.

1.3.2 Waste Materials in Drilling Fluids

A significant amount of research has been conducted regarding the use of food waste in the oil and gas drilling industry. Investigated the use of mandarin peel powder (MPP) in an eco-friendly fluid additive, as an alternative to non-biodegradable additives that harm the environment. They utilized MPP as an eco-friendly alternative fluid additive in comparison to a reference polymer, PAC-LV. The MPP additive yielded better outcomes because it was able to significantly lower the pH and reduce the fluid circulation loss with a low concentration of the powder. Thus, MPP was shown to be a good additive for lowering the pH, viscosity control, and reducing circulation loss. This study encouraged the use of food waste as a suitable alternative to the non-biodegradable chemicals that are currently used in the drilling industry. Recognized that grass, hay, and palm leaves are also viable candidates. The study verified that food waste can be repurposed to promote an environmentally friendly operation of the oil and gas drilling industry. Figure 1.3 represents the preparation of food waste as an additive for application in water-based drilling fluids.

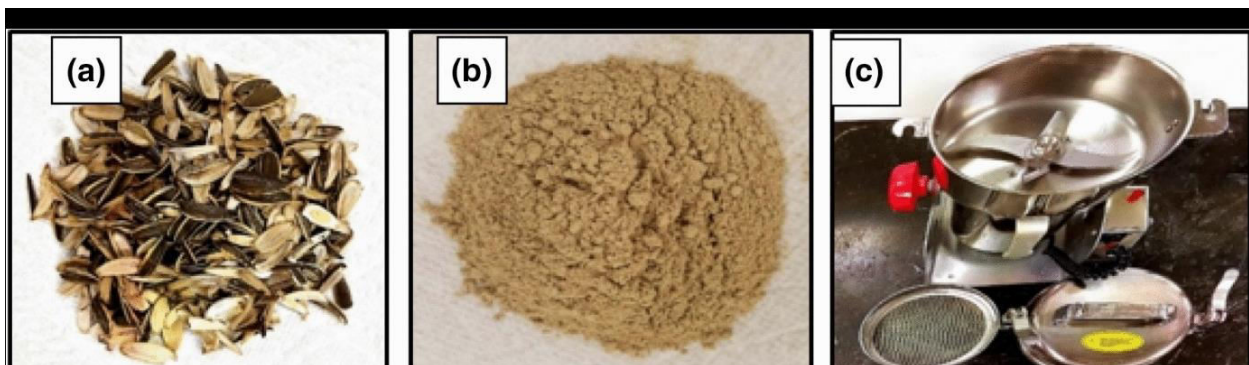


Figure 1.3. (a) Black sunflower shell raw waste converted into (b) powdered form using (c) a food processor.

The oil and gas drilling industry uses additives in drilling fluids for a variety of uses, such as pH control, and to provide rheological properties, such as plastic viscosity, gel strength, and yield point. These additives must also address issues such as circulation loss control, wellbore integrity, wellbore completion, and inhibition of corrosion to ensure a smooth drilling operation. However, at present, the chemicals used for these purposes are non-biodegradable and can cause significant negative effects on the environment. A sustainable solution would use chemicals that are biodegradable and do not cause any environmental damage, while simultaneously providing the desired properties of a good drilling fluid, as presented in Figure 4

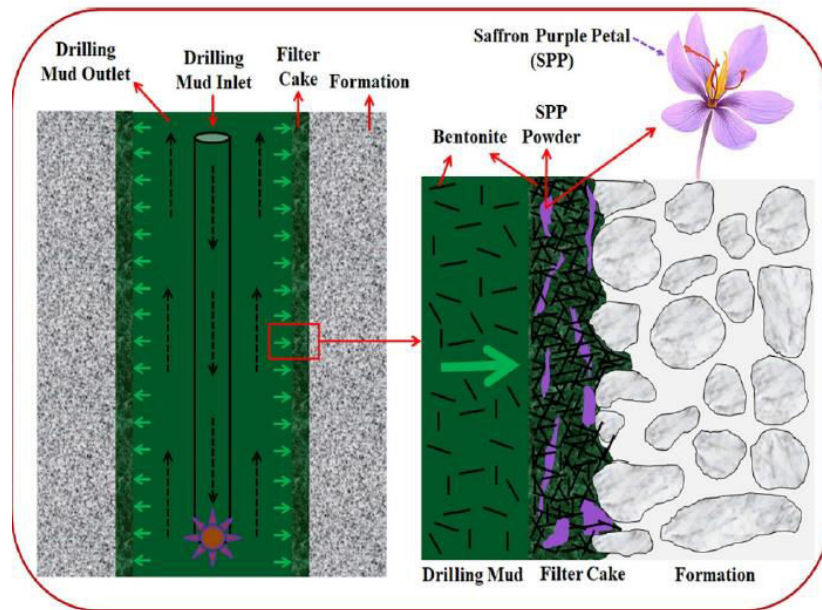


Figure 1.4. Schematic illustration of mud cake thickness and filter loss using saffron purple petals compared to bentonite based mud.

Recent studies have shown the impact of various waste-derived additives for efficient rheological properties in drilling fluids. For example, Joshi et al. reported on the use of tamarind kernel powder as an alternative additive in drilling fluids. The study outlined the impact of using tamarind kernel powder on the mud density. Mud density is one of the significant properties of drilling fluids, and helps provide and regulate wellbore stability and control formation pressure. In the study, it was stated that the density of the mud sample increases with the addition of tamarind seed powder and the combination of bentonites. Increasing the concentration of tamarind seed powder resulted in a thicker mud sample and an increase in mud density. The mud density of the samples was observed to be in the range of 8.22–8.97 ppg, which has been considered to be a suitable range for use as an additive in the formulation of drilling fluids.

1.4 Prospective Performances

1.4.1 Wellbore Instability

It is known, each year, millions of dollars are spent due to wellbore instability problems which are happening from exposure of shale to drilling fluid. The drilling fluids that contain nanoparticles have the power to depreciate wellbore instability. The nanoparticles size is less than the pore throat sizes of rocks that lead to plug the pore throats (Ibid). According to), the particle size should not be higher than one-third of the pore throat to build a bridge and plug the pores.

1.4.2 Lost Circulation

One of the most popular drilling problems is loss circulation. It is a partial or complete loss of the drilling fluid to the formation. This situation occurs due to naturally fractured, crevices and channels. The loss of circulation leads to increase the cost and time required for drilling to reach the target depth. The loss of circulation also causes loss of pressure control and increasing safety concerns (Ibid). Therefore; a lot of time and effort has been spent to control the loss circulation through produced additives materials or muds. The use of micro and macro particles has shown limited success. The utilization of nanoparticles led to reduce loss circulation by raising carrying capacity sufficiently to carry the cuttings efficiently and to maintain drilling fluid density and pressure over a wide range of operational conditions.

1.4.3 Pipe sticking

Sometimes the drill pipe stuck to the wall of the borehole due to cutting accumulation when drilling fluid circulation stops or because the filtrate loss in the wall of the wellbore. Pipe sticking has a significant impact on the drilling performance and well costs. Many parameters are affected on the pipe sticking which are dependent on drilling fluid rheology. Any change in any rheology property can cause pipe sticking (Ibid). The nano-fluids can play a role in recovering the stuck pipe. Nanomaterial's based drilling mud have the potential to decrease the sticking tendency of



mud cakes by making a thin film covering the drill pipe that lead to cutting down the pipe sticking problem. Also, nano-fluids have excellent carrying capacity, thus reducing the pipe sticking by cleaning the wellbore from cuttings.

1.4.4 Reduction Torque and Drag

There is a noteworthy boost in torque and drag difficulties due to the clash between the drill string and the borehole. Micro and macro materials based drilling muds have limited power to overcome torque and drag problems. On the other hand, the application of nanoparticles leads to a significant reduction of the friction between the pipe and the borehole (Donald & Frank, 2007). Nano-fluids have the potential to form slightly lubricating film in the wall pipe interface (Ibid).

1.4.5 Toxic Gases

Nanoparticles can be employed in drilling fluids to rid of toxic and corrosive gases, like hydrogen sulphide. This gas should take away from the drilling fluids in order to cut environmental contamination as well as to protect the health of drilling staff and to prevent corrosion of drilling equipment's. have found that the addition of 14 to 25nm zinc oxide particles into drilling muds removes hydrogen sulphide completely while bulk zinc oxide remove only 2.5% and take more time.

1.4.6 Technical and Economic Benefits from Using Nanomaterials in Drilling Fluid

In addition to the enhance drilling fluid performance, the most engaging features of nanomaterial are their low cost This is imputable to the amount of nanomaterials required for any utilization is, much less which results from the fact that nanoparticles have a very huge surface area to mass ratio that enhances the reactivity of nanomaterials. Also, the using of nanoparticles in drilling fluids has technical and economic benefit. Technically, nanofluids are suitable to use in new oil production techniques and to overcome severe drilling operations. Economically, the use of nanoparticles can affect through three aspects. The first one is the use of nanoparticles instead of expensive additives reduces the drilling fluids cost. Also, the use of nanofluids as drilling fluids was enhanced oil recovery by reaching deep challenge formations. As well as, the non-productive time was shortened due to an elimination of troubles, thus saving huge costs.

II. HISTORICAL REVIEW OF DRILLING FLUID DEVELOPMENT

It is useful to recognize the chronological succession of issues that contribute to the various developments in a drilling fluid industry before moving deeper into details. In the past, early drilling operations used water to remove the cuttings from the hole. This was reported in 1846 when Fauvelle drilled a well in France by using flushed water. Nevertheless, the role of water alone as a drilling fluid was only partly successful in removing cuttings and achieved limited drilling depth. Hence; the inability of water in this application promoted the researchers and oil companies to produce new fluids. The real basis of drilling fluid science was started by the Chapman idea of using water and plastic material as drilling fluid which successfully formed a strong wall around the reservoir (Chapman, 1890). Moreover, the first development was produced in 1901, when a well was drilled by using a mixture of clay and water (Offshore technology report). As a result, in 1935, Harth (1935) introduced bentonite clay and this innovation takes the basis of current drilling fluids.

2.1 Drilling Fluids and Rheological Properties

The principal functions of drilling fluids include removal of drill cuttings and cleaning of the wellbore, lubricating and cooling the drill bit and string, maintaining wellbore formation, and preventing well blowout. Thus, the drilling fluid plays a significant role in the upstream oil and gas industry. As a major success factor of drilling processes, the properties of drilling fluids are constantly monitored and adjusted as recommended by the American Petroleum Institute (API) Recommended Practice 13B-1 for WBDF and Recommended Practice 13B-2 for OBDF. Based on API Recommended Practice 13B-1, the International Organization for Standardization (ISO) has prepared and outlined the ISO 101,414 under the general title of Petroleum and Natural Gas Industries Field Testing of Drilling Fluids (API, 2009). ISO 10,414 outlines the standard procedures to regularly determine and monitor the mud properties to ensure maximum drilling performance. These procedures are improved and periodically revised with the emergence of newer studies and developments.

2.2. Mud Density or Weight

The mud density or weight is an important property of drilling fluids that functions to improve wellbore stability and maintain formation pressure. Low mud density can lead to shear failure of rocks, known as a borehole breakout, which



subsequently collapses the wellbore. However, reported the possible loss of circulation, decrease in rate of penetration, and formation damage due to excessive mud density values. Thus, researchers have worked to develop a reliable route, i.e., the PSO-ANN model, to estimate the most suitable density of drilling fluids under HTHP wellbore conditions.

2.3 Plastic Viscosity

Viscosity measures the internal resistance of drilling fluids, whereas PV is the flow resistivity caused by friction between the solid particulates in drilling fluids and fluid layers. PV is dependent on the viscosity of the base fluids, i.e., water and oil, and the concentration of solids. In short, an increase in mud weight or solid content in drilling fluids results in higher PV, which is undesirable because it lowers the drilling speed. The adverse effects caused by PV have been reduced by the addition of water or a thinning additive.

2.4 Yield Point

YP is defined as the measured degree of shear thinning performance of non-Newtonian drilling fluids. It is the ability to carry drill cuttings in suspension while circulating in the wellbore and out of the annulus. Hence, drilling problems such as differential sticking can be prevented. The solid additive particles reduce in size, the YP increases. This is due to the increased attractive forces between solid particles which enhance the carrying capacity of drill cuttings and cleans the wellbore.

2.5 Gel Strength

Gel strength (GS) measures the forces of attraction between particles in static conditions, unlike YP which measures them in dynamic conditions. Therefore, gel strength refers to the ability to suspend drill cuttings during connections or other static conditions. As it increases over time, more pressure is required to overcome the accumulated gel strength and initiate the circulation.

III. DRILLING FLUID DEFINITIONS, FUNCTIONS AND TYPES

There is a wide range of drilling fluid definitions, depending on function, composition and complexity. The American Petroleum Institute (API) defines the drilling fluid as a circulating fluid employed to save any or all of the various responsibilities involved in drilling operations in rotary drilling. The drilling fluid can also be defined as all compositions that used to remove the cuttings from a borehole. In addition, it can be defined as a complex fluid that consists of a multitude of additives. The form and the quantity of additives are based on the drilling technique and the formations of a reservoir (Ibid). In drilling operations, drilling fluids are utilized to remove cuttings from a borehole and transport it to the surface, to stabilize and support wellbore, and to cool and lubricate the drill bit. In addition, drilling fluids play a role in suspending cuttings when not circulating and controlling formation pressure. Furthermore; drilling fluids protect the environment by preventing inflow-outflow of fluids between a borehole and the reservoir formation. The challenges during drilling operations in the petroleum industry have contributed to the formulation of different types of drilling fluids. All the same, the primary ingredients of these fluids are water, oil and gas in addition to chemical additives. More often than not, the drilling fluids are classified as water-based mud, oil-based mud and gas-based mud. According to the most popular drilling mud used in drilling is water-based mud (WBM) while, oil-based mud (OBM) is usually used in swelling shale formation. In WBM, particles are suspended in water or brine. OBM is used in swelling shale formation because with WBM, the shale will absorb the water, as a consequence of this it expands and this expansion may cause stuck pipe. However, there are drilling special conditions under which a liquid drilling fluid is not a suitable circulating medium. Therefore; foam, air and gases may be employed in drilling some wells when these conditions exist (Ibid). In this situation, the drilling fluid type is called gas based mud (GBM).

IV. RESULT AND DISCUSSION

Demonstrated the use of environmentally-friendly okra as a viable alternative additive in drilling fluids. The performance of okra as an additive was evaluated with the absence and presence of clay in drilling fluids. Comparatively, the incorporation of okra in clay-based drilling fluids presented a greater improvement in the rheological properties compared to that in clay-free drilling fluids. In clay-based drilling fluids, the addition of 2 and 3 g of okra resulted in an increase in plastic viscosity (PV) of more than 100%, compared to the addition of 2 g of starch, which only yielded a 45.7% increment. Increasing the concentration of okra also led to an increase in the yield point of drilling fluids. However, was observed that starch is more efficient in improving the yield point than okra. Fluid loss was evaluated at different concentrations and observed to be reduced at different proportions for each concentration. In addition, the filter cake thickness was reduced with the addition of okra, with further reductions evident at higher concentrations, as shown in Figure 4.1a–d.

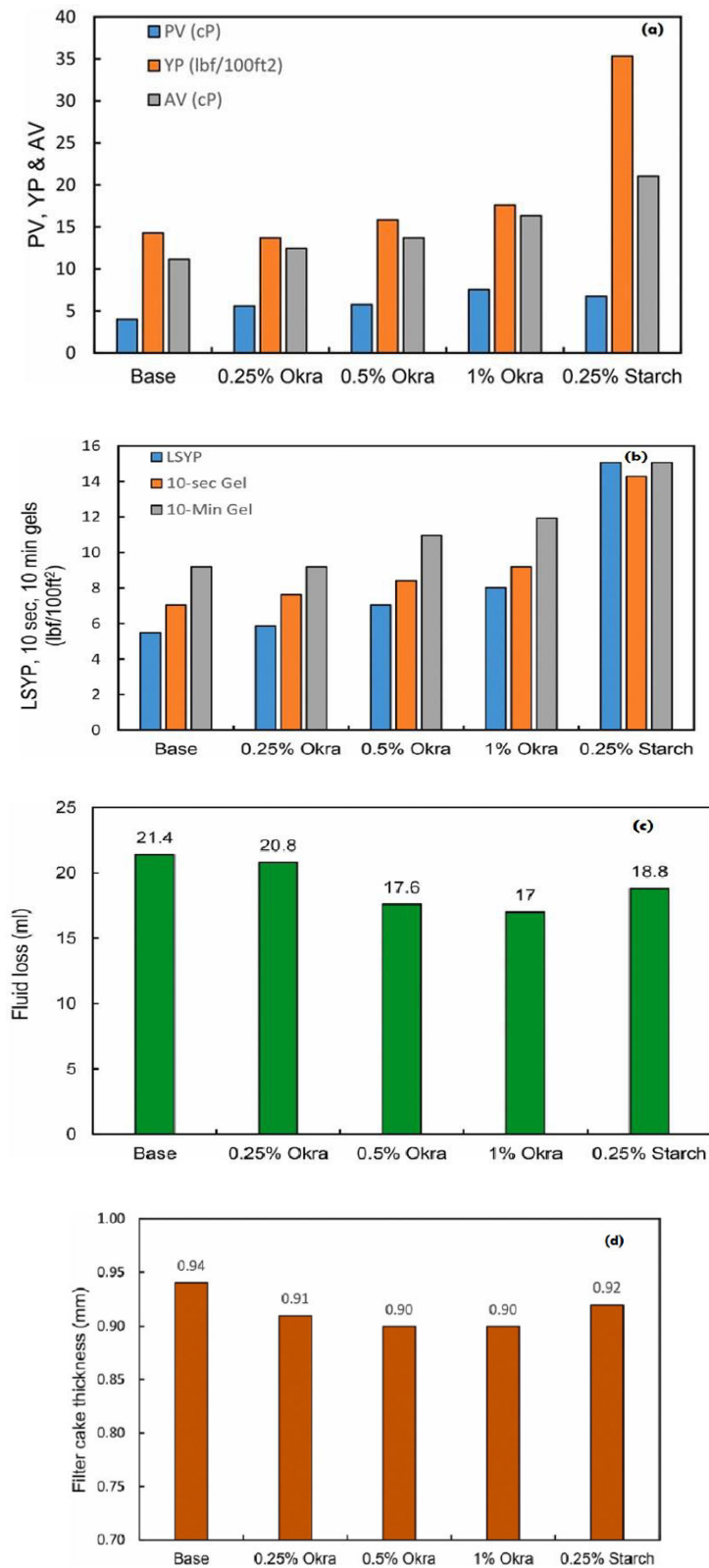


Figure 4.1 . Graphical representation of okra powder as an eco-friendly additive in water-based drilling fluids.

Increase in plastic viscosity, yield point, apparent viscosity, and gel strength (a,b), and decrease in fluid loss and mud cake thickness (c,d), using various additive concentrations (%) of okra powder versus starch. Similarly, proposed



sustainable saffron purple petals (SPP) as an eco- friendly alternative for additives in drilling fluids. The addition of SPP powder in drilling mud resulted in an effective increase in PV values. As the concentration of SPP powder increases, the PV value also increases. Additionally, the introduction of SPP powder to drilling mud also dramatically enhances the yield point compared to that of base mud. The incorporation of SPP powder into drilling mud demonstrated excellent filtrate loss, whereby the filtrate volume was reduced gradually with increasing concentration of SPP powder. The addition of SPP powder in the drilling mud also resulted in the reduction of mud cake thickness compared to that in base mud. The above-mentioned studies have demonstrated the effectiveness of food waste in drilling fluid additives as a substitute for the environmentally hazardous materials currently in use within the industry. In this regard, there is a need to promote the “waste to wealth” concept by studying the potential of using unused waste derivatives as additives in drilling fluids, and to address the issue by exploring the additives’ rheological properties, which ensure it is viable and cost effective.

4.2 Chemical Additives

Chemical additives are added to drilling fluids in order to enhance its performance by changing the properties and composition, particularly when circumstances need mud with special capabilities to optimize the oil production process. Several mud additives exist some performing more than one function. The most common additives are: pH control to control the acidity and alkalinity of the fluids, bactericides to reduce the bacterial count and corrosion inhibitors to prevent corrosion and the formation of scale in drilling fluids. In addition, defamers are used to reduce foaming action, emulsifier to make a mixture of two liquids and a filtrate loss to reduce water loss to the formation. Also, flocculants are used to settle out the solids, lubricants to reduce the friction coefficient, and lost circulation materials to plug the zone in the formation.

4.3 Limitations of Drilling Fluids and Challenges

There are still limitations during use these traditional drilling fluids in spite of the chemicals added to improve the drilling fluid performance. The main limitations of water based drilling fluids are: the ability of WBM to dissolve salts which may result in an unwanted jump in density. Moreover, the WBM is capable of interfering with the flow of gas and oil through porous media. Other limitations are the ability of WBM to promote the disintegration and dispersion of clays and the inability of WBM to drill through water sensitive shale. As well as the ability of WBM to corrode iron such as drill pipes, drill collars and drill bits. Just like water based mud, oil-based drilling fluids have limitations such as the fluids are very expensive from several aspects, as the constituents of this type of mud are very expensive and the high cost of treatment cuttings and disposal of it. On the other hand, this type is not favourable to the surroundings because their disposal may result in the pollution of water bearing aquifers, pollution of lands, and the decimation of the coral reefs. Furthermore; this type of fluids is unsuitable for use in dry gas reservoirs. Not only do WBM and OBM have limitations, but GBM is also likely to experience a number of limitations. The most common one is a high risk of explosion due a high pressure that may be generated because the phase of SBM is gas or foam. Besides, this type causes drilling string corrosion. As well the SBM cannot be used through water bearing formations because the cuttings will aggregate together in these formations, therefore it is impossible to carry out by air or gas. Oil well drilling technology has evolved from vertical, horizontal to sub-sea and deep-sea wells. These specific drilling techniques require specialized drilling fluids to fulfill the objectives. The traditional drilling fluids are suitable for low and medium temperature and pressure conditions. Although oil based drilling fluids were used in high temperature and pressure because of their stability, but these fluids are likely to experience a number of deteriorations such as gelation, degradation of weighting materials and breakdown of polymeric additives under HTHP conditions. This debasement of the fluids in these conditions decreases drilling performance by deceleration of the rates of penetration and this creates intractable problems that lead to leaving behind most of the oil unrecovered.

4.4 Drilling Fluids for HTHP Conditions

Drilling fluid should have appropriate high temperature transfer and flow properties. Besides, it must be friendly to the environment in order to perform the functions in an effective responsible. Recently, these specifications have been achieved, with some limitations as mentioned before, by water-based and oil based muds. Both have betonies clay and some of the chemical additives. These additives may improve density, decrease corrosion rate, change viscosity, and stop bacterial growth (Hawker, 2001). However, for deep-well drilling the temperatures and pressures can be very high and the heat transfer requirements on the drilling fluid impossible to meet. In this situation, to design a drilling fluid has capability to work successfully; it is required to significantly enhance the fluid’s thermal properties. Nanotechnology offers light, strong and corrosion-resistant materials which is what the drilling fluid industry needs. The application of



nanoparticles in drilling fluids will enable the drilling engineers to adjust the drilling fluid rheology by modifying the composition, type, or size distribution of nanoparticles in drilling fluid to accommodate any special situation. Materials manufactured from nanoparticles are not like those prepared using their larger equivalents. Nanomaterials are stronger and more reactive than other materials. They also conduct heat efficiently. The reason behind that is the increased surface interaction. As, for given quantities of material, there are a higher number of particles as a result of their size reduction as well as there is more surface area to bear the heat.

4.5 Nanomaterials Based Drilling Fluid

The beginning of nanotechnology has revolutionized the science and engineering sectors due to its vast range of applications. The oil production industry like every other industry can take out massive benefits from nanotechnology. One of the most encouraging prospects is the use of nanoparticles in drilling muds so as to have a clear operational performance, stability, and suitability. These features make drilling fluids adopt well with a wider range of operating conditions by minor changes in composition and sizes (Ibid).

Amanullah and Al-Tahini (2009) define nanomaterial's based drilling fluids as mud containing additives with particle sizes between 1 to 100 nanometers; also they classified the nano-fluids into simple and advanced nano-fluids based on the concentration of the nanoparticles in drilling fluids. Nanoparticles in drilling fluids can play a major role in fixing the most common problems during drilling like wellbore instability, lost circulation, pipe sticking, toxic gases, high torque and drag.

V. CONCLUSION

To sum up, drilling fluids have been used to serve many purposes in the drilling process and it as blood in human bodies. However, there are problems with wellbore instability, lost circulation, pipe sticking, toxic gases and high torque; with continued using of these fluids with unconventional reservoirs. During the last decades, scientists and researchers discovered nanotechnology and nowadays there are attempts to apply this technology in the drilling process. This paper has explained the drilling fluid functions, types and the purpose of adding additives. In addition, it has clarified the degradation of drilling fluids during high temperature and high-pressure conditions. From this article, it can be inferred that nanoparticles can enhance drilling fluids due to their stability of the rheological properties at high pressure and high temperature conditions. The nano drilling fluid can cause a revolution in oil and gas drilling industry because it can fulfil the specific needs of new drilling technologies and it can hit the target depth in less time. One of the main limitations in this paper is that has ignored a mention of the sizes and the concentrations of nanoparticles that used in drilling fluid because the article's purpose is review of important role that nanoparticles did in drilling fluids rather than research. Likewise, each circumstance or problem would need to use nanomaterials with specific sizes and concentrations. Future work could be borne out in the field of property measurements to establish a better comparison study. The cost feasibility of using nanoparticles in drilling fluids can also be research.

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