Cairo University

IMPROVEMENT OF A LOCAL SUSPENDED BENTONITE BEHAVIOUR TO MEET THE STANDARD SPECIFICATIONS AS A DRILLING FLUID

By

Eng/ Ahmed Mohammed Mohammed Elnady Hussein

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
MINING ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

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Key Words:
Drilling mud, Montmorillonite, Activation , Rheological properties , Zeta potential

Summary:
The most drilling fluids used were the water based mud. Water based mud was contained mainly from Sodium bentonite. Local bentonite is a calcium bentonite with low swelling properties . The kneading process succeeded to activate the local bentonite to Sodium bentonite using 2.5 gm of Soda ash. The Rheological properties was improved using 0.15 gm of CMC ,0.15 gm of CTAB ,0.12 gm of PA and 0.9 gm of Sodium hydroxide to exceed the API standard for drilling fluids . Temperature ranging between 25 and 80 °C at atmospheric pressure affects significantly the rheological behavior of the water base mud.

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Abstract

Oil and gas are the most important sources for energy. Countries all over the world has a big interesting in discovery and utilizing this sources of energy. The drilling process need fluid called drilling fluid . Drilling fluids are the essential element in drilling industry. They perform many functions like transporting rock cuttings to surface, lubricating the drill bit, applying hydrostatic pressure in the well bore to ensure well safety and minimizing fluid loss and sealing the permeable formations by forming a filter cake on the wall of the well. The selection of the proper drilling mud depends on many factors such as formation ,temperature and the pressure of the fluid in pores, but the most considered factors are the total cost and environmental impact. Recently, drilling companies interested in environmental safety, water base mud is environmentally friendly. Water base mud is the common fluid used nowadays. The main parameter of its performance is the sodium content in bentonite . A good quality bentonite should contain mainly more than 80% of Montmorillonite.

This work focused on the activation and improvement of the Egyptian calcium bentonite (clay minerals) in order to upgrade the ore up to the API specifications.

The evaluation involved the study of the rheological , filter loss properties and gel strength before and after improvement with viscosities and filter loss agents. Different additives and concentrations were tested. Sodium hydroxide and cationic surfactant Cetyl Trimethyle Ammonium Bromide (CTAB) , Polymers such as Carboxymethyl cellulose (CMC) and Polyacrylamide (PA) were used with various amounts to examine their effect on the Rheology properties. It is found that by increasing the concentration of Sodium hydroxide the rheological properties increased. Polymers tried were found to improve the rheological properties to meet with API specifications.

The effect of pH studied and found that the increasing in pH accompanied by increasing in Rheological properties. The electrokinetics properties were examined for activated bentonite and it is found that the bentonite surface has a negative surface charge. The surface charge values were varied in all the measured samples depending on the type of additives and the pH. It was found that changing the surface charge of the particles by adding different additives could be control the viscosity of the suspended bentonite. Subsequently it managed to improve the specifications of the drilling fluid.

Chapter 1: Introduction

The successful drilling of an oil well economics depends on the properties of the drilling fluid. Drilling fluids are suspensions that are used during the drilling of ground wells. They provide primary well control of subsurface pressures by a combination of density and any additional pressure acting on the fluid column .They are most often circulated down the drill string, out the bit and back up the annulus to the surface so that drill cuttings are removed from the wellbore. The most widely used name is “mud” or “drilling mud". The cost of the drilling fluid itself is relatively small, but the choice of the right fluid and maintenance of the right properties while drilling profoundly influence the total well costs. For example, the number of rig days required to drill to total depth depends on the rate of penetration of the bit, and on the avoidance of delays caused by caving shales,stuck drill pipe, loss of circulation, all of which are influenced by the properties of the drilling fluid. In addition, the drilling fluid affects formation evaluation and the subsequent productivity of the well.

1.1 Functions of Drilling Fluids

Many requirements are needed on the drilling fluid characteristics . The first purpose of the drilling fluid was to act as a carrier to remove cuttings from the bore hole, but now the diverse applications for drilling fluids make the assignment of specific functions difficult. [1].

In rotary drilling, the principal functions performed by the drilling fluid are :

• Carrying cuttings from beneath the bit. Drilling fluids transport cuttings from the well bore as drilling progresses. Many factors influence the removal of cuttings from the hole. The velocity at which fluid travels up the annulus is the most important hole cleaning factor. The annular velocity must be greater than the slip velocity of the cuttings for the cuttings to move up the well bore.

The size, shape, and weight of a cutting determine the viscosity necessary to control its settling rate through a moving fluid. Low shear rate viscosity strongly influences the carrying capacity of the fluid and reflects the conditions most like those in the well bore. The drilling fluid must have sufficient carrying capacity to remove cuttings from the hole.

The density of the suspending fluid has an associated buoyancy effect on the cuttings. An increase in density increases the capacity of the fluid to carry cuttings. [2].

• Cooling and lubricating bit and drilling string. Considerable heat is generated by rotation of the bit and drilling string. The drilling fluid acts as a conductor to carry this heat away from the bit and to the surface. Current trends toward deeper and hotter holes make this a more important function. The drilling fluid also provides lubrication for the cutting surfaces of the bit thereby extending their useful life and enhancing bit performance. Filter cake deposited by the drilling fluid provides lubricity to the drill string, as do various specialty products. Oil and synthetic base fluids are lubricious by nature.

- Maintaining the stability of uncased sections of the borehole. A fluid helps establish borehole stability by maintaining a chemical and mechanical balance.
Chemical interactions between the exposed formations of the borehole and the drilling fluid are major factor in borehole stability. Borehole formation hydration can be the primary cause of hole instability, or a contributing factor.
The hydrostatic pressure exerted by the drilling fluid is normally designed to exceed the existing formation pressures. The desired result is the control of formation pressures and a mechanically stable borehole.

- Preventing the inflow of fluids oil, gas, or water from permeable rocks penetrated. It is extremely important to evaluate how drilling fluids will react when potentially productive formations are penetrated. Whenever permeable formations are drilled, a filter cake is deposited on the wall of the borehole. The properties of this cake can be altered to minimize fluid invasion into permeable zones. Also, the chemical characteristics of the filtrate of the drilling fluid can be controlled to reduce formation damage. Fluid–fluid interactions can be as important as fluid formation interactions. In many cases, specially prepared drilling fluids are used to drill through particularly sensitive horizons. Form a thin, low-permeability filter cake that seals pores and other openings in formations penetrated by the bit.

- Assist in the collection and interpretation of information available from drill cuttings, cores, and electrical logs.

- Support Partial Weight of Drilling string or Casing. The buoyancy effect of drilling fluids becomes increasingly important as drilling progresses to greater depths. Surface rig equipment would be overtaxed if it had to support the entire weight of the drilling string and casing in deeper holes. Since the drilling fluid will support a weight equal to the weight of the volume of fluid displaced, a greater buoyancy effect occurs as drilling fluid density increases.

- Control Subsurface Pressure As drilling progresses, oil, water, or gas may be encountered. Sufficient hydrostatic pressure must be exerted by the drilling fluid column to prevent influx of these fluids into the borehole. The amount of hydrostatic pressure depends on the density of the fluid and the height of the fluid column, i.e., well depth.
The following formulae can be used to calculate the total hydrostatic pressure at any given depth or fluid density:
Hydrostatic Pressure (psi) = 0.052 × Depth (ft) × Fluid Density (lbm / gal)

1.2 Composition of Drilling Fluids

Drilling fluids are classified according to their base into:

• Water-base mud. Solid particles are suspended in water. Oil may be emulsified in the water, in which case water is termed the continuous phase.
• Oil-base mud. Solid particles are suspended in oil. Water or brine is emulsified in the oil. Oil is the continuous phase.
• Gas. Drill cuttings are removed by a high-velocity stream of air. Foaming agents are added to remove minor inflows of water.[3].

1.3 Drilling Fluid Selection

The main factors dominating the selection of drilling fluids are:
• The types of formation to be drilled
• The range of temperatures
• Strength, permeability and pore fluids pressure exhibited by the formation.
In addition to the above, selection of the drilling fluid can be informed through consideration of other factors such as - production concerns, environmental impact, safety and logistics, the most important factor that dominates selection of drilling fluid is the overall well cost.
The cost is an important factor in selection of the type of drilling fluids the water based mud is preferred to use and Could be discharged directly into the environment.

1.3.1 Water Based Mud

This basic system is essentially bentonite and water. Usually, this system is used to spud a well. As drilling continues, formation solids are incorporated into the drilling fluid. Solids-removal equipment is used to remove as much of the formation solids (drill solids) as possible.

1.3.2 Bentonite Mineralogical Composition

Bentonite is a geological term for soil materials with a high content of a swelling mineral, which usually is Montmorillonite. The remaining part of the bentonite may vary in mineralogy and especially between different quarries and depends basically on the geochemical conditions during the formation of the bentonite. Typical accessory minerals present in bentonite are other clay minerals, quartz, calcite, pyrite, feldspars, gypsum and various iron oxides/hydroxides.

The Montmorillonite mineral belongs to the smectite mineral group, in which all members have an articulated layer structure and swelling properties. Common for the smectite group is that the thickness of an individual mineral layer is around 1 nm and the extension of the other two directions may be up to several hundred nanometers. Each layer is composed of a central sheet of octahedral coordinated cation, which on both sides are linked through shared oxygen's to sheets of tetrahedral coordinated cation. Minerals of this type are often referred to as 2:1 layer structures. (Figure 1.1)