DRILLING FLUIDS FUNCTIONS

INTRODUCTION

Mud Engineer

Drilling fluids are becoming so specialized, most companies now have a mud engineer on duty at all times to keep the mud in good condition. The Mud Engineer:

- is responsible for testing the mud and for prescribing mud treatments in order to keep mud weight, properties, and chemistry within recommended limits.
- must give detailed recommendations in order to optimize the achievement of technical and economical drilling aims

DRILLING FLUID FUNCTIONS

Should:

1. Remove drill cuttings from wellbore
2. Control formation pressure
3. Maintain wellbore stability until casing can be run and cemented
4. Cool and lubricate drillstring and bit
5. Transmit hydraulic power to bit

Should Not:

6. Hamper formation evaluation techniques
7. Cause adverse effects on the formation being penetrated (Formation Damage)
8. Cause corrosion of the tubulars

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

Viscosity

- Viscosity and fluid rheological properties have a determinant effect on well cleaning.
- Cuttings settle rapidly in low viscosity fluids (such as water) and as a result, their removal is difficult.
- Generally, higher viscosity fluids are required to improve cuttings transport capacity
- The property related to the viscosity is the thixotropy. It means that a mud (thixotropic fluid) can become like a gel under static condition and return to sol (fluid) in dynamic situation. This characteristic can suspend the cuttings during the situation when the mud is not being circulated, as for flow check or pipe connection or repairing
- Viscosity is dependent on concentration, quality, and dispersion of suspended solids in the mud.

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

Velocity

- **Definition:** The rate (or speed) at which the mud is circulated (dependant on pump capacity, pump speed, borehole size, and DP size)
- The higher the fluid velocity the faster the cuttings will reach the surface

Transport velocity = Annular velocity – Slip velocity

(More on velocity under “Hydraulics” section)

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

Particle Suspension

- Drilling fluid must also keep drill cuttings in suspension when the mud is not being circulated (e.g., during a connection)
- The propety that keeps particles in suspension is called “gel strength”.
- Gel strength required to hold the cuttings in suspension should be no more than required however. When circulation resumes, the fluid must be fluid enough to release the particles at surface.
- Cuttings that settle when circulation has stopped can cause bridges that result in a stuck string.

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

Thixotropic

- **Definition:** The property exhibited by certain gels of becoming fluid when stirred or shaken and returning to the semi-solid state upon standing.
- Most drilling fluids are thixotropic. This means that they undergo a gelification process in static conditions. This process allows the drilling fluid to keep cuttings in suspension during pipe connections and other times when the mud is not moving.
- Shear-thinning fluids with high viscosity are the most effective for well cleaning at low annular velocity.

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

Density

- Density has a positive effect on removing drill cuttings: the higher the density of the mud, the more buoyancy.
- More buoyancy means greater carrying capacity to prevent the cuttings from falling through the mud and to lift them to surface
- High density fluids can clean the hole very well with low annular velocity
- However, a mud heavier than necessary to balance the formation pressure has a negative impact on drilling operations, so weighting up the fluid just to remove cuttings must be avoided

DRILLING FLUID FUNCTIONS

1. Remove Drill Cuttings from Wellbore

USE THIXOTROPIC FLUIDS WITH “SHEAR THINNING” PROPERTIES WITH A STRONG LOW-SHEAR-RATE VISCOSITY (LSRV) AND PLUG FLOW CONDITIONS

USE A HIGH FLOW, LOW VISCOSITY FLUID TO OBTAIN TURBULENT FLOW

- An easy method to determine if drilled solids are being effectively removed by the mud is to compare the sand content at the flow line and at the mud suction.

DRILLING FLUID FUNCTIONS

2. Control Formation Pressure

Density

- One of the main functions of drilling fluid is to keep the formation pressure under control
- The pressure exerted by the mud column in static conditions (without circulation) is called hydrostatic pressure.
- Hydrostatic pressure is the product of the mud weight and the True Vertical Depth (TVD) of the well. If the hydrostatic pressure of the column of drilling mud is equal to or higher than the formation pressure, formation fluids can’t flow into the wellbore

DRILLING FLUID FUNCTIONS

2. Control Formation Pressure

Density

- Formation pressure typically increases with depth
- To compensate for this we increase the density of the mud with barite
- Mud weight must be limited to the minimum necessary to control the well, maintain its stability, and still stay below the fracture gradient

DRILLING FLUID FUNCTIONS

2. Control Formation Pressure

Density

The pressure gradient of a normal formation can vary from:

- 0.436 psi/ft [1.03 kg/cm$^{2/}$10 m] (8,59 lb/gal) for onshore wells
- 0.465 psi/ft [1.07 kg/cm$^{2/}$ 10 m] (8,95 lb/gal) for off-shore wells

DRILLING FLUID FUNCTIONS

3. Maintain Wellbore Stability

Caving

- Wellbore stability is a function of mechanical, physical (pressure and tension), and chemical characteristics
- Overhangs, ledges, and vertically-dipping formations may break off and fall into the hole if a high differential (pressure or density) exists between the formation and drilling fluid
- Swelling clays and heaving shales decrease drilling rate, and increase the possibility of stuck pipe and fishing jobs

DRILLING FLUID FUNCTIONS

3. Maintain Wellbore Stability

- The cement job is a determining factor to effective isolation between formations, and to guarantee a reliable completion.
- The mud must maintain the condition of the hole so casing can be run and cemented without causing completion problems.
- When running casing, the mud must be fluid and at the same time minimize the annular pressure losses in order to avoid loss of circulation caused by induced fractures.

DRILLING FLUID FUNCTIONS

4. Cool and Lubricate the Drillstring and Bit

Circulation of the drilling fluids cools the bit and the drillstring assembly, to temperatures lower than the bottom-hole temperature

- Mechanical and hydraulic energy generated by pumping mud to the bit, and abrasion between the drill string and the hole, produces a great amount of heat
- Since the formation is a poor conductor the heat has no where to go
- Circulating fluid helps to dissipate this heat at surface
- Because of the composition of the mud, it has a lubricating effect which also cuts down on the heat production. Indicators of poor lubrication are high torque and drag

DRILLING FLUID FUNCTIONS

5. Transmit Hydraulic Power to Bit

Hydraulic Power is Used to:

- Maximize penetration rate (ROP)
- Remove cuttings from under the bit and up to the surface
- Run downhole motors and other special equipment
- The hydraulic program is based on using the right diameter nozzles in the bit, the pump's efficiency, and choosing the proper circulation pressures and rates for the hole conditions

DRILLING FLUID FUNCTIONS

6. Guarantee Adequate Formation Evaluation

Logging

- The type and composition of mud in the hole determines the quality of data from the electric logs that measure the electrical, sonic, nuclear and magnetic-resonance properties of the formations
- Precise formation evaluation is mandatory, without it we must core, run DSTs, and conduct flow tests. All these formation evaluation methods are affected by the drilling fluids.

DRILLING FLUID FUNCTIONS

7. Minimize Formation Damage

Main Causes of Formation Damage

- Mud or drilling solids that invade deep into the matrix of the formation, permanently obstructing its porosity and permeability
- Swelling shales, which reduce permeability
- Precipitation of solids that result from the reaction between the mud filtrate and formation and completion fluids (such as brines or acids), which limit permeability
- Emulsions formed by contact between the mud filtrate and formation fluids, which can limit permeability

DRILLING FLUID FUNCTIONS

7. Minimize Formation Damage

Seal off Permeable, Porous, and Fractured Fms

- Permeability is a measure of the capacity of a porous media (such as a rock) to allow fluid to flow through it.
- When the pressure of a mud column is greater than the formation pressure, liquid and solid components of the mud invade the formation and form a filter cake against the borehole wall
- In highly porous and permeable formations, the mud can easily invade the formation.

DRILLING FLUID FUNCTIONS

7. Minimize Formation Damage

Filter Cake

- Solids in the mud will form a barrier (skin effect) on the borehole wall of the formation.
- The filter cake is composed of solids from the drilling fluid
- The filter cake should be thick enough to seal the formation, but it also must be thin enough to avoid causing drilling problems.

DRILLING FLUID FUNCTIONS

7. Minimize Formation Damage

Potential Problems with a Thick Filter Cake

- Tight hole
- Increased torque and overpull
- Poor log quality
- Drillstring failure

DRILLING FLUID FUNCTIONS

7. Minimize Formation Damage

Treating a Thick Filter Cake

- Calcium Carbonate (removable with acid washing)
- Cellulose
- And a wide range of seepage loss
- Other additives (LCM)

DRILLING FLUID FUNCTIONS

8. Control Corrosion

- Because the drill string and casing are constantly in contact with the drilling fluid and well fluids, they are constantly subject to corrosion
- Electrolysis, stress, contaminants such as soluble salts, dissolved oxygen, carbon dioxide, or hydrogen sulphide can cause severe corrosion, either deep in the well or on surface
- Use oxygen scavengers, scale inhibitors, ironite sponge, zinc oxide
- Easiest to maintain high pH: 9.5 to 10.5
- Most solutions only slow the corrosion down, none can solve it

DRILLING FLUID FUNCTIONS

- Range of additives

- Bentonite
- Natural and synthetic polymers
- Asphalts and gilsonit
- Deflocculant organic additives lignosulfonate CMC and starches

DRILLING FLUID FUNCTIONS

- In a drilling fluid system, the mud properties must keep the essential functions and at the same time minimise problems in the well.
- The topics developed in this chapter are a guideline for the **selection** of the fluid.
- The **selection** of a drilling fluid must be based on generic experience and developed in site experiences

DRILLING FLUID FUNCTIONS

The **selection** regarding the type of mud is based on:

- Drilling problems
- Possibility of converting the mud in use to another type of mud
- Cost
- Products availability
- Environmental factors
- Case histories

DRILLING FLUID FUNCTIONS

Mud Properties VS Functions

- The characteristics of a mud can influence its functions e.g. the formation pressure is checked by the hydrostatic pressure. The hydrostatic pressure is modified by the density or specific weight.
- As the **uncontrolled density** increases, the pressure drop increases. The consequence is a possible **loss of circulation**.

DRILLING FLUID FUNCTIONS

Mud characteristics modifications

Fluids engineering always need an exchange of conditions to treat and keep optimum drilling. For instance, an out of proportion viscosity increasing, improves the hole cleaning:

- The loss of pressure increases
- The capacity of removing solids in the mud decreases
- The penetrating rate slows down
- The dilution treating increases a/o the preparation, with consequent costs increasing