Drilling mud

From Wikipedia, the free encyclopedia

Driller pouring Super Foam down the rod string on a drilling rig

Drilling mud, a type of **drilling fluid**, also known as **spud mud**, is a fluid used in operations to drill boreholes into the earth. Often used while drilling oil and natural gas wells and on exploration drilling rigs but can also be used for much simpler holes, such as water wells. The main classification scheme used broadly separates the mud into 3 categories based on the main component that makes up the mud:

1. 'Water Based Mud' (WBM). This can be sub divided into *Dispersed* and *Non-Dispersed*
2. 'Non Aqueous' or more commonly 'Oil Based Mud' (OBM) this also includes synthetic oils (SBM).
3. Gaseous or Pneumatic mud.

Contents

Details of Use


Typical Shale Shakers on a drilling rig

On a drilling rig, mud is pumped from the *mud pits* through the drill string where it sprays out of nozzles on the drill bit, cleaning and cooling the drill bit in the process. The mud then carries the crushed rock ("cuttings") up the annular space between the drill string and the sides of the hole being drilled, up through the surface *casing,* and emerges back at the surface. Cuttings are then filtered out at the **shale shakers** and the mud returns to the *mud pits*. The returning mud can contain natural gases or other flammable materials. These can collect in and around the shale shakers area or in other work areas. There is a potential risk of a fire, an explosion or a detonation occurring if they ignite. In order to prevent this safety measures have to be taken. Safety procedures, special monitoring sensors and explosion-proof certified equipment has to be installed, e.g. explosion-proof certified electrical wiring or control panels. The mud is then pumped back down and is continuously recirculated. After testing, the mud is treated periodically in the mud pits to give it properties that optimize and improve drilling efficiency.

Function

The main functions of a *Drilling Mud* can be summarised as follows:

Remove cuttings from well

Drilling fluid carries the rock excavated by the drill bit up to the surface. Its ability to do so depends on cutting size, shape, and density, and speed of fluid traveling up the well (annular velocity). These considerations are analogous to the ability of a stream to carry sediment; large sand grains in a slow-moving stream settle to the stream bed, while small sand grains in a fast-moving stream are carried along with the water. The mud viscosity is another important property, as cuttings will settle to the bottom of the well if the viscosity is too low.

Other properties include:

- Most drilling muds are thixotropic (i.e. they gel under static condition). This characteristic keeps the cuttings suspended when the mud is not moving during, for example, maintenance.
- Fluids that have shear thinning and elevated viscosities are efficient for hole cleaning.
- Higher annular velocity improves cutting transport. Transport velocity = annular velocity – slip velocity
- High density fluids may clean hole adequately even with lower annular velocities (by increasing the buoyancy force acting on cuttings). But may have a negative impact if mud weight is in excess of that needed to balance the pressure of surrounding rock (formation pressure), so mud weight is not usually increased for hole cleaning purposes.
- Higher rotary drill-string speeds introduce a circular component to annular flow path. This helical flow around the drill-string causes drill cuttings near the wall, where poor hole cleaning conditions

occur, to move into higher transport regions of the annulus. Increased rotation are the best methods in high angle and horizontal beds.

Suspend and release cuttings

- must suspend drill cuttings, weight materials and additives under a wide range of conditions.
- drill cuttings that settle can causes bridges and fill, which can cause stuck-pipe and lost circulation.
- weight material that settles is referred to as sag, this causes a wide variation in the density of well fluid. More frequently occurs in high angle and hot wells.
- high concentrations of drill solids are detrimental to;
  - drilling efficiency (it causes increased mud weight & viscosity which in turn increases maintenance costs and increased dilution)
  - Rate of Penetration (ROP) (increases horsepower required to circulate)
  - mud properties that suspended must balanced with properties in cutting removal by solid control equipment.
- for effective solids controls, drill solids must be removed from mud on the 1st circulation from the well. If re-circulated, cuttings break into smaller pieces and are more difficult to remove.
- conduct a test to compare the sand content of mud at flow line and suction pit (to determine whether cuttings are being removed).

Control formation pressures

- if formation pressure increases, mud density should also be increased, often with barite (or other weighting materials) to balance pressure and keep the wellbore stable. Unbalanced formation pressures will cause a blowout from pressured formation fluids.
- hydrostatic pressure depends on mud weight and True Vertical Depth. If hydrostatic pressure is greater than or equal to formation pressure, formation fluid will not flow into the wellbore.
- well control means no uncontrollable flow of formation fluids into the wellbore.
- hydrostatic pressure also controls the stresses caused by tectonic forces, these may make wellbores unstable even when formation fluid pressure is balanced.
- if formation pressure is subnormal, air, gas, mist, stiff foam or low density mud (oil base) can be used.
- in practice, mud weight should limited to the minimum necessary for well control and wellbore stability. If too great it may fracture the formation.

Seal permeable formations

- when mud column pressure exceeds formation pressure, mud filtrate invades the formation, and a filter cake of mud is deposited on the wellbore wall.
- mud is designed to deposit thin, low permeability filter cake to limit the invasion.
- problems occur if thick filter cake is formed, including tight hole conditions, poor log quality, stuck pipe, lost circulation and formation damage.
- in highly permeable formations with large pore throats, whole mud may invade the formation, depending on mud solids size;
  - use bridging agents to block large opening, than mud solids can form seal.
  - for effectiveness, bridging agents must be over the half size of pore spaces / fractures.
  - bridging agents (i.e calcium carbonate, ground cellulose).

- depending on the mud system in use, a number of additives can improve the filter cake (i.e bentonite, natural & synthetic polymer, asphalt and gilsonite).

Maintain wellbore stability

- chemical composition and mud properties must combine to provide a stable wellbore. Weight of mud must be within the necessary range to balance the mechanical forces.
- wellbore instability = sloughing formations can cause tight hole conditions, bridges and fill on trips (same symptoms indicate hole cleaning problems).
- wellbore stability = hole maintains size and cylindrical shape.
- if the hole is enlarged, it becomes weak and difficult to stabilize, causes problems (low annular velocities, poor hole cleaning, solids loading and poor formation evaluation)
- in sand and sandstones formations, hole enlargement can be accomplished by mechanical actions (hydraulic forces & nozzles velocities). Reduced by conservative hydraulics system. Good qualities filter cake containing bentonite to limit the enlargement.
- in shales, mud weight is usually sufficient to balance formation stress, and wells are usually stable. With water base mud, chemical differences cause interactions between mud & shale and can lead to softening. Highly fractured, dry, brittle shales can be extremely unstable (leading to mechanical problems).
- various chemical inhibitors can control mud / shale interactions (calcium, potassium, salt, polymers, asphalt, glycols and oil – best for water sensitive formations)
- oil (and synthetic oil) based drilling fluids are used to drill most water sensitive Shales in areas with difficult drilling conditions.
- to add inhibition, emulsified brine phase (calcium chloride) drilling fluids are used to reduce water activity and creates osmotic forces prevent adsorption of water by Shales.

Minimizing formation damage

- skin damage or any reduction in producing formation natural porosity and permeability (washout)
- most common damage;
  - mud or drill solid invade formation matrix
  - swelling of formation clays within reservoir, reduce permeability
  - precipitation of solids of mud filtrate to formations fluids or to the other fluids forming insoluble salts
  - mud filtrate & formation fluids forming an emulsion (blocking reservoir pores)
- specially designed drill-in fluids or workover and completion fluids, minimize formation damage.

Cool, lubricate & support the bit and drilling assembly

- heat is generated from mechanical and hydraulic forces at bit and when drill-string rotate and rub against casing and wellbore.
- cool and transfer heat away from source and lower to temperature than bottom hole.
- if not, bit, drillstring and mud motors would fail more rapidly.
- lubricity base on Coefficient of friction. Oil and synthetic base lubricate better than water base mud (but can improve if WBM added lubricants).
- amount of lubrication provided by drilling fluid depends on type & quantity of drill solids and weight materials + chemical composition of system.

- mud aeration, foaming and other O_2 trapped conditions cause corrosion damage in short period time.
- when drilling in high H_2S, elevated the pH fluids + sulfide scavenging chemical (zinc).

Facilitate cementing and completion

- cementing is critical to effective zone and well completion.
- during casing run, mud must remain fluid and minimize pressure surges so fracture induced lost circulation does not occur.
- mud should have thin, slick filter cake, wellbore with no cuttings, cavings or bridges.
- to cement and completion operation properly, mud displace by flushes and cement. For effectiveness;
    - hole near gauges
    - mud low viscosity
    - mud non progressive gel strength

Minimize impact on environment

Mud is, with varying degree, toxic. It is also difficult and expensive to dispose of in an environmentally-friendly manner. A Vanity Fair article (http://www.vanityfair.com/politics/features/2007/05/texaco200705?currentPage=5) described the conditions at Lago Agrio, a large oil field in Ecuador where drillers were effectively unregulated. Texaco, the drilling company, left the used mud (and associated cuttings and crude oil) in unlined open-air pits, allowing it to contaminate both surface and underground waters. Storing mud properly is very expensive. After a decade of drilling, Texaco considered transferring the mud waste at Lago Agrio to concrete-lined pits, but estimated that it would cost over 4 billion dollars (US).

Summary

a) Mud Selection

- select drilling fluid system for particular well
- cost, availability of products and environmental factors

b) Mud Properties vs Functions

- different properties affect particular function
- must recognized and design their influence on all function and relative importance for each function

c) When Functions Clash

- always requires tradeoffs in treating and maintaining the properties needed to accomplish required functions
- how to improve one function while minimizing the impact of mud property changes on other functions