Name: Measurement of Drilling Fluid Density using Mud Balance

Objective:
To measure the density of drilling fluid (mud) using a mud balance and compare the results with theoretical values.

Apparatus/Materials Required:
Mixing Container, Mechanical Stirrer, Measuring cylinder, Weighing Balance, Water, Salt, Viscosifier, Additives, low-gravity solids, weighting materials. Mud Balance apparatus, Graduated scale.

Theory:
Drilling fluid, commonly known as drilling mud, is a critical component in oil and gas well drilling. It serves several purposes, such as

i) Transport cuttings and cavings to surface.
ii) Control subsurface pressures.
iii) Help suspend weight of drill string and casing.
iv) Providing wellbore stability
v) Facilitating wireline logging and cementing.

The composition of drilling fluid varies based on the base fluid, which can be water-based (WBM) or oil-based (OBM). Additives like viscosifiers, shale stabilizers, weighting agents and filtration control agents are included to enhance fluid performance. Formulating an optimal drilling fluid involves determining the right proportions of water, salt, viscosifier, additives, low-gravity solids and weighting materials to achieve the desire density and stability. Proper mixing is crucial to ensure uniformity and functionality

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The mud balance is an essential tool for determing the density of drilling fluids. Density is defined as weight per unit volume and is a critical parameter for controlling subsurface pressures and stabilizing the wellbore. The mud balance operates on the principle of lever mechanics, balancing the filled mud cup against a counterweight and adjustable rider to measure density.

Procedure:

a) Drilling Fluid Formation.

→ Clean the mechanical stirrer and mixing container thoroughly before use

→ Measure liquid components using a measuring cylinder and solid components using a calibrated weighing balance for accuracy

→ Add the required amount of water to the mixing container.

→ Gradually add salt and mix at low speed for 90 seconds.

→ Sequentially add viscosifier, additives, LCGS, and weighting material with a 5-minute interval between additions. Mix at increasing speeds based on fluid's viscosity

→ Continue mixing until a uniform composition is achieved

→ Transfer the prepared fluid into a separate container.

→ Clean the stirrer and mixing container properly after use.

b) Measurement using Mud Balance.

→ Clean and calibrate the mud balance using freshwater.

→ Ensure the bubble indicator is centered for accurate readings.

→ Remove the lid from the mud balance cup and fill it completely with the test fluid.

→ Replace the lid securely, ensuring excess fluid is expelled.

→ Wipe the cup clean of any adhering fluid.

→ Place the balance arm on a fulcrum.

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→ Adjust the rider until the arm is level, indicated by the bubble in the centre of level.
→ Record the density value ~~read~~ from the graduated scale.
→ Conduct multiple trials to ensure consistent results

Calculations:

Given data:

→ Water-Based Mud → ρ_f = 1lb-bbl (350ml)

→ Fluid density = 10 ppg = 1.2 sg

→ Salt = 75,000ppm = 7.5%

→ Barite Density = 4.2 sg

→ Additive details:

i) Viscosifier = 1 sg, 1g/350ml

ii) Filtration Control Agent = 1.2 sg, 2 g/350ml

iii) Low Gravity Solids = 2.6 sg, 15 g/350ml.

Formulae used

→ $\rho_f = V^f_{Brine}\rho_{Brine} + V_{additive}\rho_{additive} + V^f_{Barite}\rho_{Barite}$

→ $V_f = V_{Br} + V_{Barite} + V_{additive}$

→ $M_{Br} = M_w + M_{salt}$

→ $V_{Br}/V_w = (100/\rho_{Br})/(100-x)$

Now from additive details:

V_{add} (vol fraction) $= \frac{1}{1} + \frac{2}{1.2} + \frac{15}{2.6} = 8.4358$ ml/350ml

Now from salt table, For NaCl

For weight % = 7% Density = 1.049 kg/l

weight% = 8% ρ = 1.056 kg/l

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$\therefore \rho_{Brine} = 1.052$ sg

$$\frac{V_{Br}}{V_w} = \frac{(100/1.052)}{(100-7.5)} = 1.0276$$

Now from $V_f = V_{Br} + V_{add} + V_{Barite} \Rightarrow 350 = V_{Brine} + 8.4358 + V_{Barite}$

$\therefore V_{Brine} + V_{Barite} = 341.56 \quad — (1)$

Now from $V_f \rho_f = V_{Br} \rho_{Br} + V_{add} \rho_{add} + V_{Barite} \rho_{Barite}$

$\therefore 350 \times 1.2 = 1.052 \times V_{Br} + V_{add} \times 4.2 + 2.133$