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APPLICATION OF DRILLING FLUID

EDITED BY

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Preface

Subterranean wells are drilled by petroleum industry using fluids called drilling fluids. By combining density and any additional pressure (surface- or annular-imposed) acting on the fluid column, they serve as the fundamental regulator of subsurface pressures. To remove drill cuttings from the wellbore, they are typically circulated down the drill string, out the bit, and back up the annulus to the surface. The industry uses a variety of slang phrases, acronyms, and alternate names for drilling fluids. The two phrases "mud" and "drilling mud," which are the most commonly used names for it, shall be used interchangeably throughout this chapter. Water-based mud (WBM), oil-based mud (OBM), synthetic-based mud (SBM), non-aqueous fluid (NAF), inversion emulsion fluid (IEF), high performance water-based mud (HPWBM), drill-in fluid (DIF), and reservoir drilling fluid (RDF) are some other names and acronyms for drilling fluids.

The effectiveness of the drilling programme depends in large part on the drilling fluid, which warrants thorough examination. Numerous publications are available from drilling fluid material suppliers, and the technical literature of the oil and gas business has a large number of papers. Performance and function of drilling fluid Drilling fluids can be as simple as water or oil or as complicated as systems based on compressed air, pneumatic fluids, or both. Hydraulic energy is transmitted to the drill bit and downhole tools. The drill string and bit are cooled and lubricated. Adequate formation evaluation is permitted. A wellbore that will produce hydrocarbons is provided.

The execution of these tasks is influenced by the kind of drilling formation and the different drilling fluid parameters. Compromises are frequently required because of a number of circumstances. The intricacy of the well being drilled, the pressures and temperatures below the surface, logistics, cost, and local expertise all play a role in the choice and design of a specific drilling fluid and its attributes. The drilling equipment being utilized has an impact on drilling fluid performance as well. The hydraulics available for the drilling operation and the well design should be taken into consideration while adjusting the drilling fluid's qualities. Optimizing the hydraulic horsepower at the bit can increase bit life and rate of penetration (ROP), particularly for roller cone bits. When a sufficient flowrate is employed with little to no overbalance, the ROP and bit life for polycrystalline diamond compact (PDC) cutter bits are improved. The parasitic pressure losses in the drill string and the available pressure at the bit for optimal drilling performance are determined by the characteristics of the drilling fluid and its circulation rates. The density of the mud and the type of suspended materials have an impact on the ROP as well. Control of mud qualities requires frequent, thorough tests. The drilling program's effectiveness depends on how well the results of these tests and treatments are interpreted in order to preserve the proper fluid characteristics.

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CHAPTER - 1

NON-DAMAGING DRILLING FLUID (NDDF)

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Non-Damaging Drilling Fluid (NDDF) is a technology for increasing oil output by minimising drilling formation damage. The NDDF is a silt and barite-free polymeric mud solutions that's also predominantly used in the pay zone portion to minimise formation damage and preserve reservoir stability. In the system, long-chain, high molecular weight polymers are utilised to encapsulate drill materials and prevent dispersion, as well as to cover Shales for inhibition, enhance viscosity, and minimise fluid loss [1]–[3].

Dehydration causes a highly compacted, extremely low permeability mud cake to build on the top of the rocks, rapidly shutting off the pay zone's permeable channels. This drilling mud is frequently employed to dig the pay zone portions of development wells; it is also utilised to prevent formation damage in horizontal drilling. It was originally employed at the Linch field, a Mehsana asset of ONGC Ltd. in India's North Cambay Basin. The structure with the least amount of damage has a better chance of producing oil [4]–[6].

While all hydrocarbon reservoirs are susceptible to damage, many, such as sandstone, are much more susceptible to drilling mud and therefore more susceptible to formation damage. To compensate for formation damage, NDDF must contain the following. Non-biodegradable compositional clay, barite, and other similar materials are prohibited; a minimum drill fine solids is needed; an effective control on polymer particle incursion into the pay zone is required; and filtering loss is eliminated. Filtrate is not chemically interacting with formation fluid to generate insoluble precipitate; lowest feasible progressing gel formation for reducing total mud invasion throughout trips as well as gel breaking calculations; filtrate is not chemical interacting with fracturing fluid to produce insoluble precipitate. Drill-in fluids are drilling fluids (either water-based or oil-based) designed specifically for pay zone drilling operations and are believed to be non-destructive to producing formations.

In other words, drilling fluids must be designed to produce an impermeable and thin exterior filter cake that opposes the intrusion of filtration or small particles. Furthermore, traditional drilling fluid additives should be substituted with non-harmful substitutes. For example, the inclusion of bentonite, a conventional rheology additive, is not authorised in the composition of drilling fluids. It is instead replaced with less hazardous alternatives [7]–[9].

NDDF is a polymer mud solution that is devoid of barite and clay and is used in the borehole's pay zone to protect formation integrity and avoid formation damage. It is composed of long-chain polymers (usually biopolymers) with a high molecular weight, which may absorb drilled materials and prevent them from dispersing, as well as form a filter cake on Shales, increase fluid viscosity, and decrease fluid loss. The fluid comprises particles of various sizes that dehydrate and strongly bond together to form a well-compacted exterior filter cake (mud cake). This mud cake builds on the surface of the exposed wellbore rocks and seals the permeable zones of the pay zone.

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The interchange of fluid reservoir and well fluids may occur throughout the drillin process. Because it's usually desirable to limit or regulate this, the NDDF generates an external filter cake on the borehole walls with extremely low permeability. This will block and isolate formation and wellbore fluids, preventing drilling fluid from infiltrating the pay zone and reducing formation damage and circulation loss. Prior to production, this external filter must be removed, increasing the surface area of the hydrocarbon flow and lowering the skin factor. Various additives are incorporated in the fluid to change and enhance the drilling fluid's qualities. Certain acidic materials are introduced to the fluids, and these solids can settle in the pores of the wellbore wall and block them. Certain polymers are employed as additives to seal the walls of the wellbore (like a coating) and thereby decrease the drilling fluid's incursion into the formation. Water-based muds with primarily polymeric additions (biopolymers are sometimes employed) and bridging components are the most non-damaging drilling fluids (such as calcium carbonate).

Drilling fluid, also known as drilling mud in geotechnical engineering, is employed to help in the boring of wellbores into the soil. Drilling fluids are commonly utilised when drilling natural gas and oil wells as well as on exploratory drilling rigs, but they are also employed for much basic boreholes, including water wells. Drilling mud has the purpose of transporting cuttings out of the hole. Water-based muds (WBs), that are either dispersed or non-dispersed; non-aqueous muds, often known as oil-based muds (OBs); as well as gaseous drilling fluid, that can include a broad variety of gases, are the three primary types of drilling fluids. Together with formatives, they are employed in drilling diverse oil and gas deposits with suitable polymer and clay additives.

Drilling fluids' primary functions involve preventing formation fluids from having entered the well bore, maintaining the drill bit nice as well as clean all through drilling, having to carry out drill cuttings, and halting drill cuttings whilst also drilling is hesitated and when borehole arrangement is decided to bring into and out of the hole. The drilling fluid used for a certain project is chosen to minimise formation damage and corrosion. On a daily basis, several different kinds of drilling fluids are employed. Some wells need the use of several kinds at different points in the hole, or the use of some types in conjunction with others. The numerous fluids are classified into a few major categories:

Pressurized air is pushed either through the annular space of the bore hole or down the drill string itself. The same as before, but with adding water to improve viscosity, clean the hole, offer greater cooling, and/or manage dust.

Air/polymer: To generate certain circumstances, a specifically prepared chemical, most often referred to as a kind of polymer, is added to the water and air combination. A polymer is an example of a foaming agent.

Water: Water is occasionally used on its own. Seawater is often utilised in offshore drilling to drill the upper portion of the hole.

Water-based mud (WBM): Most simple water-based mud systems start with water, then add clays and many other compounds to form a homogenous mix that resembles something between chocolate milk as well as a malt (depending on viscosity). The clay is often a blend of natural clays dispersed in the fluid during drilling and specialised kinds of clay processed and marketed as WBM system additives. The most prevalent of them is bentonite, sometimes known as "gel" in the oilfield.

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Gel most likely refers to the fact that when the liquid has been pushed, it may be extremely thin and free-flowing (like chocolate milk), but once the pumping is turned off, the static fluid forms a "gel" structure that opposes flow. Whenever sufficient pumping power is provided to "break the gel," flow restarts and the fluid recovers to its free-flowing condition. Many different chemicals (for example, potassium formate) are introduced to a WBM system to accomplish a variety of effects, including viscosity control, shale stability, increased drilling rate of penetration, and equipment cooling and lubrication.

Oil-based mud (OBM) is a kind of mud in which the base fluid is a petroleum product such as diesel fuel. Oil-based muds are employed for a variety of reasons, including better lubricity, improved shale blocking, and improved cleaning capability with lower viscosity. Oil-based muds may also sustain higher temperatures without degrading. The application of oil-based muds requires unique considerations, like cost, environmental problems including removal of cuttings in a suitable location, and the exploratory drawbacks of utilising oil-based mud, particularly in wildcat wells. So because base fluid cannot be separated from the oil that is recovered from the formation, using an oil-based mud interferes with the geochemical study of cuttings and cores, as well as the calculation of API gravity.

Synthetic-based fluid (SBM): Also known as Low Toxicity Oil Based Mud (LTOBM). A synthetic-based fluid is a mud with a synthetic oil as the basis fluid. This is most often employed on offshore rigs since it has the qualities of an oil-based mud but has far lower toxicity than an oil-based fluid. This is critical when the drilling team is working with fluid in a confined location, such as an offshore drilling rig. The same environmental and analytical issues apply to synthetic-based fluid as they do to oil-based fluid.

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CHAPTER - 2

DRILLING FLUID AND ADVANTAGES OF NDDF

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The drilling fluid reduces well production by causing extensive formation damage. In order to prevent the entrance of formation fluid into the wellbore, those fluids are kept at pressures higher than the formation pressure. This overbalance pressure causes the solids as well as filtration to penetrate the development and cause harm to the development as a result. In addition, the filtrate could respond with the forming minerals to mobilise and then re-deposit them, moisturise the clay minerals surrounding the forming particles, and it may start generating scales as a result of the reaction among filtrate as well as formation liquid going to lead to a decreasing rock permeability. The fine solids (drilling fluid's compositional solids, drilled cuttings, and polymers' particles) could insert the porous gullets to reduce formation permeability [1]–[3].

In water-sensitive clay particles and shale deposits, the traditional water-based mud can lead to wellbore instabilities, formation damage, torque as well as drag, blocked pipes, logging and primary cementation failures, borehole washouts, etc. In directed or horizontal wells, such issues might become substantially worse. Additionally impractical from an environmental and economic standpoint is the alternative use of oil-based mud. Additionally, oil businesses are drawn to environmentally friendly, biodegradable drilling fluids because of the strict environmental standards and regulations that are now in place. Invasive solids are one of the main reasons drilling fluids harm formations, according to studies. When back-flushing, small particulates are difficult to remove since they penetrate deeply [4]–[6].

An ideal drilling fluid must decrease fluid loss, minimise drilled fine solids in the mud, start producing inhibitive saline filtrate that would not grow the clay engulfs in the formation particles, must not react with formation fluid to start generating insoluble precipitate, must contain specialised sized components to prevent formation damage, and shouldn't use dispersant as well as non-degradable fine solids like clay, barite, etc. It is shown that the Non-Damaging Drilling Fluid (NDDF), a polymer mud system devoid of clay & barite, should be used in the pay zone portions to prevent formation damage and also to maintain the pay zone or reservoir. It integrates long-chain, high-molecular-weight biodegradable plastics into the systems to either coat the shales to impede flow or encapsulate drill solids to prevent dispersion. It also increases viscosity and lowers fluid loss.

In terms of formation damage control, NDDF provides significant advantages over traditional scattered muds, as seen below:

1. Conventional muds contain fine particles that penetrate deep into to the deposit and impede the flow of oil from source to well. Fine solids (clay) are not found in NDDF.

2. Mud filtrate swells the clay envelope around the sand grains in the target zone. As a consequence, the oil flow is impeded. Clay swelling is avoided because NDDF creates a saline inhibiting filtrate.

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3. In NDDF, suitably sized calcium carbonate ($CaCO_3$) particles bridge the pore mouths on the formation surface, generating an external filter cake. Exterior filter cakes are considerably simpler to remove by drawing down than inner filter cakes inside the forming matrix.

4. Calcium carbonate is also employed to improve the relative density of NDDF (instead of barites used in conventional muds). Calcium carbonate melts in acid and may be removed afterwards.

5. The presence of dispersant causes tiny clay particles to accumulate within the formation matrix, which subsequently migrate and plug the pores. Because NDDF includes no dispersant, there is no blocking caused by particulates created during dispersion.

Although the terms "fluids" and "drilling muds" are frequently used synonymously, drilling fluids and muds are favoured by the majority of drilling businesses and writers. The industry uses a variety of terminologies to define drilling fluids without putting any limitations on the composition or the qualities of the drilling fluids. The following list includes a few definitions that are accessible and are culled from various sources:

The fluid used to assist in the creation and removal of cuttings from a borehole in the ground is referred to as a drilling fluid. A drilling fluid is a fluid that has been chemically manufactured to have certain chemical and physical properties for circulation during the rotary drilling process, according to the Baker Hughes Drilling Fluids Reference Manual. The drilling fluid, according to the American Petroleum Institute (API), is a circulating fluid used in drilling holes to carry out any or all of the different tasks necessary for drilling operations. Any variety of liquid, gaseous, and mixes of fluids and solids used in operations to drill boreholes into the ground are referred to as drilling fluids, based on the Schlumberger Oilfield Glossary.

It is important to note that the industry's broad definition, devoid of restrictions, has allowed for the development of novel drilling fluid compositions and qualities throughout drilling history. One of every drilling operation's most crucial components is drilling mud. To guarantee safety and a low amount of hole issues, the mud's many functions must all be optimised. Failing of the mud to fulfil its intended roles might prove to be very expensive in terms of time and resources, as well as put the well's successful completion in jeopardy and potentially cause serious issues like stopped pipes, kicks, or blowouts.

The three primary types of drilling fluids are gaseous drilling fluid that can contain a variety of gases, non-aqueous muds, often known as oil-based muds (OBs), and water-based muds (WBs), which can be both dispersed as well as non-dispersed. These are utilised in conjunction with their formatives, as well as the proper polymer and clay additives, to drill different oil and gas formations. For a well to be properly, safely, and inexpensively drilled, a drilling fluid must perform a variety of roles.

The makeup of drilling fluid varies depending on the needs of the wellbore, the capabilities of the rig, and environmental considerations. Drilling fluids are designed by engineers to optimise drilling parameters such as penetration level and hole cleaning, regulate subsurface pressure, reduce formation damage, reduce the possibility of lost circulation, control erosion of the hole, and control subsurface pressures. Furthermore, since a significant portion of current wellbores are highly divergent, drilling fluid technologies must assist in addressing challenges with hole cleaning and stability unique to these wells.

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Since their introduction into the rotary drilling process between the years of 1887 and 1901, drilling fluids have experienced tremendous progress in a variety of areas to keep up with the evolution of drilling technology. As a consequence of this progress, there are now more varieties of drilling fluid readily accessible, necessitating ongoing revisions to the categorization criteria.

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CHAPTER - 3

FUNCTIONS OF DRILLING FLUID

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The drilling mud must carry out the following essential duties. By applying hydrostatic pressure larger than the formation pressure, subsurface pressures may be controlled. This attribute is influenced by the weight of the mud, which is in turn influenced by the kind of solids introduced to the fluid that makes up the mud and the thickness of the continuous liquid phase. To clean the hole of the drilling debris. Cuts removal is influenced by the viscous qualities known as "Yield Point," which affect the load capacity of the moving mud, and "gels," that hold the clippings suspended while the mud is static. Another important factor in cleaning the hole is the mud's flow velocity [1]–[3].

To grease the drillpipe and drill bit and to cool them. Drilling fluid assists in lubricating and cooling the bit as it moves through and within the revolving drilling assembly. Drilling fluid receives thermal energy transfer that causes it to heat up and go to the surface. Heat exchangers just at surface may well be utilised to chill the drilling mud in sweltering drilling settings. To avoid the hole's walls collapsing down. This purpose is accomplished by creating a stable mud coating on the borehole wall walls, similar to plastering a room's walls to prevent flaking.

To put the cuts and the measuring materials on hold when circulation is interrupted (gelation). Low shear viscosity characteristics and gels give this feature [4]–[6]. To ensure wellbore stability, borehole is employed. Controlling density, limiting hydraulic erosion, and managing clays are the fundamental elements of wellbore stability. The mass of the drilling mud is somewhat overbalanced against the pore pressure of the deposit to preserve thickness. By weighing cleaning needs, fluid capacity, and annular rate of flow, engineers aim to minimise hydraulic erosion. Clay control is a difficult task. While certain clays in some formations disintegrate in the presence of water, others grow. By changing the drilling fluid's characteristics, these impacts may be somewhat managed. Regardless of the method employed, managing the fluid's impact on the deposit aids in maintaining the integrity of the cuttings, the hole, and a relatively clean, more readily managed drilling fluid. To reduce the strains that result from swelling when mud reacts with shale formations. This response might result in wellbore instability due to hole erosion or collapse. The "inhibition" nature of the drilling mud allows for a reduction in wellbore instability.

Transporting cuttings to the surface

The primary purpose of drilling fluid is to carry drill cuttings to the surface. To achieve this, the fluid must possess sufficient suspension characteristics to prevent cuttings and commercially added solids, such barite weighing material, from settling during static periods. In order for the drilled materials to be effectively removed at the surface, the fluid has to have the right chemical characteristics to aid avoid or reduce the dispersion of the solids. The producing zone may be harmed, and drilling efficiency may be hindered, if these materials do not dissolve into ultrafine particles.

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Avoid well-controlled problems

The wellbore is under hydrostatic pressure from a column of drilling fluid in the well. To aid in preventing a flood of gas or other formation fluids, this pressure should, under typical drilling circumstances, equal or surpass the natural formation pressure. For the purpose of maintaining a safe margin and avoiding "kicks" or "blowouts," the drilling fluid's density is raised as the formation pressures rise.

The creation, however, may disintegrate if the fluid density becomes too high. Reduced hydrostatic pressure happens as a consequence of drilling fluid leakage into the resulting cracks. Additionally, an inflow from a pressurised formation may result from this pressure drop. The stability and safety of the wellbore depend on maintaining the proper fluid density for the wellbore pressure regime.

Maintain wellbore stability

Maintaining the ideal drilling fluid density not only aids in keeping formation pressures under control but also hinders hole collapse and shale destabilisation. In order to allow the drillstring to flow easily into and out of the hole, the wellbore should be free of impediments and tight spaces (tripping). When casing is run to the bottom of a hole section and then cemented after it has been drilled to the desired depth, the wellbore should stay stable under static circumstances. The density and physicochemical qualities most likely to provide the greatest outcomes for a specific interval should be indicated by the drilling-fluid programme.

Lessen formation damage

Drilling operations expose the producing formation to drilling fluid, as well as any particles and chemicals that may be present in that fluid. The formation will inevitably include some fluid filtrate and/or fine particles. But with appropriate fluid design, based on testing with cored samples of the formation of interest, this invasion and the risk for formation damage may be reduced. In addition to selecting a specifically formulated "drill-in" fluid and applying professional downhole hydraulic control techniques, such as those generally used when drilling horizontal wells, formation damage may also be reduced.

All or a portion of the time during the actual drilling activities, the bit and drillstring revolve at relatively high revolutions per minute (rev/min). Drillstring friction is decreased and drillstring cooling is aided by drilling fluid flowing through the drillstring and up the wellbore annular space.

Additionally, the drilling fluid offers a certain amount of lubricity to facilitate the movement of the drillpipe and bottomhole assembly (BHA) through tight spaces that may develop as a consequence of expanding shale or across angles that are purposefully formed by directional drilling. The ideal fluid types for high-angle directional wells are oil- and synthetic-based fluids (OBFs and SBFs), which provide a high degree of lubricity. Additionally, certain water-based polymer systems have lubricity that is comparable to that of synthetic and oil-based systems.

Detail the wellbore's characteristics

Since drilling fluid constantly comes into contact with the wellbore, it provides extensive information about the formations becoming drilled and acts as a conduit for a lot of the information recorded downhole by tools on the drillstring and during wireline-logging activities carried out whenever the drillstring is out of the hole. The level of analysis that may be done on the cuttings directly depends on how well the drilling fluid maintains the clippings as they ascend the annulus. The state of the drilling fluid's physical and chemical makeup is mostly determined by these cuttings. The quality of the data supplied by wireline equipment as well as by downhole measurement and logging tools may be improved by a drilling fluid system that is optimised and aids in creating a stable, in-gauge wellbore.

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CHAPTER - 4

PROPERTIES OF DRILLING FLUID

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Everyone should be familiar with the fundamentals of drilling fluid characteristics. Mud density is defined as the weight of the mud per unit volume, and is often expressed in pounds per gallon (PPG). Hydrostatic pressure is generated using mud density to regulate drilling operations.

Viscosity: The internal resistance to fluid flow plastic viscosity are the two forms of viscosity.

The annular viscosities and whole depth both affect the mud's flow characteristics. Water may be adequate in the top hole, but more viscous fluids would be needed at deeper depths. The flow characteristics must be carefully considered in situations including deep wells, directional wells, high penetration rates, high mud weights, and large temperature gradients. With polymers or clay material, the viscosity may be increased, and with chemicals thinners or water, it can be decreased. The viscosity of a drilling fluid—or whether thick or thin it is—measures the fluid's internal flow resistance. Because drilling fluids are non-Newtonian, their viscosity does not remain constant across all shear rates. Such non-Newtonian fluids act substantially significantly from liquids that have a constant viscosity independent of shear rate, such water or oil, that are Newtonian. Non-Newtonian drilling fluids shear thinly so that their viscosity increases at low shear rates and decreases at high shear rates. Under order to drill effectively in high-shear circumstances within the drill string's small bore, it is preferable to have as little pressure losses as possible. The bigger annulus' low-shear conditions call for a higher viscosity [1]–[3].

Funnel Viscosity: The amount of time it takes for one quarts of mud to flow through a Marsh funnel with a 946 cm^3 capacity is measured in seconds (See Figure 1). In 26 seconds, a quart of water has escaped the funnel. This is a qualitative indicator of how heavy the mud specimen is, not a real measure of viscosity. Just comparative comparisons may benefit from using the funnel viscosity.

Plastic Viscosity (PV): A component of the Bingham plastic rheological model. PV is the slope of the shear stress-shear rate graph just above elastic limit. A viscometer is a piece of machinery used to gauge plastic viscosity. PV (plastic viscosity) is measured in centipoises and is calculated by subtracting the 600 rpm measurement from the 300 rpm reading (CP). Due to the low viscosity of the mud leaving the bit, a low PV implies that the mud can drill quickly. High PV is brought on by both an overabundance of colloidal particles and a viscous base fluid. Dilution may be used to reduce PV by reducing the solids content.

Yield Point: The tension necessary to initiate fluid movement, or the opposition to beginning flow, has a physical significance. On something like a plot of shear rate (x-axis) vs shear stress (y-axis), where YP is the zero-shear-rate intercept, the Bingham plastic fluid plots as a straight line (PV is the slope of the line). PV is subtracted from the 300-rpm dial measurement to generate YP, which is given as lbf/100 ft2 using viscometer dial readings at 300 and 600 rpm.

YP is used to assess how well mud can pull cuttings out of the annulus. A drilling fluid with a higher YP should be able to transport cuttings more effectively than one with a lower YP but a fluid with a comparable density.

Gel strength is the capacity of a fluid to hold itself when mud is in a static state. Before evaluating gel strength, mud should be stirred for some time to stop precipitation, then allowed to stand still for a certain amount of time (maybe 10 seconds, mins, or 30 mins), after which the viscometer should be opened at 3 rpm to read the highest reading result. There are three different gel strength numbers in a morning report: 10 seconds, 10 minutes, and 30 minutes.

The shear force necessary to start a flow after prolonged durations of static is referred to as gel strength. They serve as a gauge for the level of gelation brought on over time by the attraction interactions between particles. If the gel is strong enough, it will hang weights and drill bits during connections and other static situations. Gel strengths have an immediate impact on the surge and swabbing pressures used while establishing connections, tripping pipe, or running casing. Additionally, they influence the pressure needed to "break circulation" and the simplicity of releasing entrapped gas or air. Utilizing the same direct indicating rotating viscometer that is used to measure viscosity, gels are determined [4]–[6].

CaCl2 Concentration: Cl+ may inhibit formation swelling, hence this number must be maintained. A titration test is used to quantify it, with potassium chromate serving as the endpoints indicator with silver nitrate as the titrant. Whenever the titration hits the equilibrium point, the mud becomes red.

Retort Test: From any of this testing, two values, Saraline Water Ratio (SWR) as well as Solid Content (LGS, Barite), were produced. In the retort test skid, mud is retorted at 950 F for two hours. High temperatures have the ability to turn liquid phases into gas phases, which are subsequently transported to a condenser and condense into liquid phases. To monitor the amount of water and oil (saraline) removed, the liquid is kept in a tube with a level indicator. Additionally, the solid residue in the retort represents the solid substance in mud.

HTHP Fluid Loss: This test is used to examine how mud loses fluid over time. For 30 minutes, mud is forced through membrane filter in the HTHP filter press at a temperature of 300 F and a pressure difference of 500 psi. Filter cake should be less than 2 ml thick when it is attached to the filter paper.

Sand content: is the percentage of total mud that is made up of "sand-sized" particles, which are particles bigger than 74 microns and incapable of passing through a 200-mesh screen. The particle in question might be genuine quartz sand, sized bridging solids, LCM, coarse-sized barite particles, drilled solids, and any other particles bigger than 74 microns. A glass tube with a graded sand content marking, a funnel, & 200 mesh sieves are used to quantify sand content. It is observed to evaluate the efficiency of solids control devices, the state of the shale shaker screen, and the possibility of enhanced abrasion on mud pumps and other circulating system components, such as drill string and downhole apparatus. A number of key parameters linked to their performance should be managed and assessed in order for drilling fluids to efficiently carry out their needed activities.

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CHAPTER - 5

PRINCIPAL PROCESSES OF FORMATION DAMAGE CAUSED BY DRILLING FLUID

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By limiting formation damage while drilling, Non-Damaging Drilling Fluid (NDDF) is a technique to boost oil output. To prevent formation damage and maintain the integrity of the pay zone or reservoir, the NDDF polymer mud system is often utilised in the pay zone section. It inserts long-chain, high-molecular-weight polymers into the system toward either coat the shales to impede flow or encapsulate drill solids to prevent dispersion. It also increases viscosity and lowers fluid loss. On the surface of the rocks, a tightly compacted, very low permeability mud cake is formed by a wide variety of particle sizes that, upon dehydration, swiftly close off the permeable routes leading to the pay zone [1]–[3]. The Mehsana Asset of ONGC in India's North Cambay Basin used NDDF for the first time while drilling pay zones in the Linch field in three wells. The suggested/optimally built NDDF should therefore:

1. Minimize formation damage, cut total well expenses, and maximise output without sacrificing HSE rules.
2. In light of this, the suggested/optimally constructed NDDF –
3. Should minimise formation damage, cut total well expenses, and maximise output without ignoring HSE standards
4. Must preserve all necessary drilling fluid attributes
5. Include specialist materials in certain sizes to fill up any exposed pore holes.
6. Depose a non-damaging filter cake that may be quickly and easily removed after initial manufacturing and/or treatment with gentle oxidising and reacting chemicals.

The productivity of an oil well relies on how well formation damage is controlled during well drilling for a well geometry, specific geology, and production technique. More oil will likely be produced from a formation with the least damage. While all productive reservoirs are prone to formation degradation, those that produce via a like sandstone, matrix mechanism, are far more vulnerable to the impact of well bore fluids than those that produce through a fracturing mechanism, such lime stone [2], [4], [5]. The pay zone may be damaged by an improper drilling fluid's composition and specifications, which might therefore affect how much oil can be produced from a newly drilled well. Following is a list of the principal processes of formation damage caused by drilling fluid.

1. Formation clogging caused by clay in the drilling fluid's composition.
2. The use of drilled cuttings to fill a formation (drilled fines dispersed in drilling fluid).
3. Polymer-particle formation plugging.
4. The filtrate hydrates the clay shell that surrounds the pay zone particles. Fine particles may obstruct the formation pores due to the consequential dispersal of the clay envelope.
5. The Effect of Filtrate on Wettability.
6. Complete mud invasion into the pay zone since the circulation was cut off.

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7. The chemical interaction between the mud filtrate and the formation fluid causes scales to develop.

In order to prevent the aforementioned formation damage processes, an ideal productive drilling fluid must:

1. Use of non-biodegradable compositional fine particles, such as clay and barite, is prohibited.
2. The minimum drilled fine solids
3. Successfully preventing particles from polymer from entering the pay zone
4. An inhibitory filtrate that shouldn't cause the clay envelop surrounding the pay zone particles to expand, as well as no usage of a mud dispersant
5. Reduced loss during filtration
6. Minimum progressive gelation is required to prevent total mud invasion during excursions and gel break circulation patterns.
7. Filtrate and formation fluid don't chemically combine to produce an insoluble precipitate. NDDF, or non-damaging drilling fluid, offers all of the aforementioned formation-damage-control components throughout drilling.

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CHAPTER - 6

FUTURE OF NON- DRILLING FLUID

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Exploration of complex, fractured, and/or depleted production zones, as well as the use of new drilling techniques such as open-hole, slim-hole drilling, and so on, necessitates the development of new drilling fluids that do not damage the reservoirs and thus do not reduce the productive capacity of the wells. Polymeric additives, mud particles, drilled particles, and other particles must be avoided from reaching the formation and therefore permanently plugging the rock pores and jeopardising production. NDDFs protect the reservoir by forming a thin filter cake on its surface that is impermeable and readily removed during initial manufacturing or by the action of enzymes and acids [1]–[3].

Growing interest in novel procedures has resulted in the creation of non-damaging drilling fluids. Bridging material is the most significant component of these fluids. Bridging is necessary to commence filter cake development, and the filter cake will then restrict future filtrate and fine losses to the formation.

Because drilling fluid is an essential component of the drilling process, most issues observed during well drilling may be directly or indirectly attributable to the drilling fluids. As a result, these fluids must be properly chosen and prepared in order to play their roles in the drilling process. The ability of a drilling fluid to execute its major duties is determined by specific qualities that must be maintained consistently in order to satisfy formation requirements during drilling operations. Failure of the mud system to perform as planned may be exceedingly expensive in terms of resources and time [4]–[6].

Mud viscosity and fluid loss management are critical elements to study throughout the drilling operation. If these components are not properly cared for, drilling difficulties such as poor hole cleaning and formation damage may develop, resulting in a decrease in well production and an increase in cost. In mud formulation, various materials, chemicals, and polymers are employed to fulfil various practical mud needs such as density, rheology, fluid loss management, and so on. This research is based on one of these materials, starch (polymers) utilised for fluid loss management and as a viscosifier. Starches are carbohydrates with the general formula $(C_6H_{10}O_5)n$ that may be found in maize, wheat, oats, rice, potatoes, yucca, and other plants and vegetables. They are made up of around 27% linear polymer (amylose) and approximately 73% branched polymer (amylopectin)

Non-Damaging Drilling Fluid (NDDF) is an environmentally friendly polymer mud devoid of clay and barite. Because the components of this mud are environmentally safe and biodegradable, we may dispose of it wherever. It is obvious that the NDDF provides rheological qualities that are almost identical to or superior than those of the traditional drilling fluid. By changing the component makeup of non-damaging drilling fluid, we may get all the qualities of traditional drilling mud.

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To prevent the bacterial effect on the mud, we may apply biocides like formaldehyde, which will also lower the mud's rheological property deviation. While traditional drilling fluids can only be used once, the NDDF with biocide may be used again since its constituent parts break down more slowly. We can state that the non-damaging drilling fluids are effective, economical, environmentally benign, and quickly decomposable. Our planet may be protected from severe contamination by using this mud.

The world's reservoirs are all different from one another. In various parts of the reservoir, the traits and characteristics vary. As a result, the makeup of any component or the value of any NDDF property used to fulfil any function won't be fixed. The presence of the polymers and starch in NDDF is mostly caused by its rheological qualities, such as its plasticity, funnel viscosity, yield point, gel strength, etc., as well as its fluid loss characteristics. However, we have shown that the bacterial activities severely degrade polymers and starch, which has an unfavourable influence on fluid loss and rheological characteristics of the NDDF. Without biocide, the NDDF degrades quickly, rendering it unfit for drilling operations. As a result, when utilising NDDF for drilling, we must reduce the rate of mud biodegradation. The biocide plays a significant function in NDDF to slow down the pace of polymer and starch deterioration and keep the mud's characteristics within optimal bounds.

As technology and knowledge grow, every product or every tool can be enhanced. Similar is the case with the drilling fluid. In the future, many of the additives in this fluid can be substituted with more economical additives which could also give better results than the current set of additives. Use of poly aluminum chloride (PAC) instead of CMC, Maize Starch is an organic compound which was used in the formulation of the drilling fluid. Various biological compounds are being used in conventional drilling fluids. These could soon find their way into non damaging drilling fluids. Biopolymers are also generally cost-effective and can increase the economic feasibility of the drilling fluid. CMC used in the fluid is cellulose derivative polymer. Many such polymers can further be introduced into the drilling fluid. Biocides can be introduced to the drilling fluid to retard the degradation process and enhance the life of the drilling fluid.

NDDF is made up of a number of different additives. Each performs a distinct function that is required for NDDF to work properly. NDDF has a variety of ingredients such as:

The base fluid (distilled water) is sometimes known as the "water number." This drilling fluid is utilized as a wetting agent during the drilling operation's exterior phase. As a result, water-based mud is less likely to pollute the environment.

CMC (Carboxymethylcellulose): Modified anionic polymer which reduces fluid loss & increases viscosity. A sustainable source of cellulosic raw material, CMC is an anionic water soluble polymer. It holds water, serves as a rheology modifier, which makes a superb film forming. These qualities make it a popular option as a bio-based hydrocolloid in a variety of applications.

Calcium Carbonate ($CaCO_3$): To form a low permeable filter cake on the wellbore walls, thereby minimizing the invasion of filtrate & solid to the formation. The external filter cake minimizes fluid loss & solid invasion to the formation.

Maize Starch- Environmentally friendly & Non-Toxic, where it controls the fluid loss of the drilling mud. As an addition, starch has the potential to increase and improve the mud's

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viscosity while also regulating fluid loss. Both amylose and amylopectin are significant components that it has. Particularly viscosity and fluid-loss management, amylose aids in improving the parameters of drilling fluid.

Drilling the pay zone segment requires close attention to the mud and the circulation system. To keep the solid particles in the mud under control during drilling, all of the solid control tools, such as the de-sander, shale shaker, de-silter, mud cleaner, etc., should really be functioning correctly. If needed, we may need to adjust the composition of the mud while drilling. It is important to continuously investigate the characteristics and functions of the mud to determine whether they are meeting the criteria or not.

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CHAPTER - 7

INTRODUCTION TO DIATOMACEOUS EARTH IN DRILLING FLUID

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Global concern surrounds the contamination of seawater by intentional or unintentional oil spills. Oil spills occur more often during oil discovery, transportation, refining, and consumption as a result of the rising demand for fossil fuels. More than 3.19 million barrels of oil were unintentionally discharged into the Gulf of Mexico during the Deepwater Horizon oil disaster, the greatest oil leak in history, from April 20 to July 15, 2010. This oil layer covered the northern gulf coast. Oil stains were found in Texas, Louisiana, Mississippi, Alabama, and Florida, the five states along the U.S. Gulf coast. During an oil spill, a thick layer of low-biodegradable oil forms and quickly spreads over the ocean. The neighbouring ecosystems and marine biota are at risk from this floatable layer [1]–[3].

Several methods have been developed to clean up oil spills. Bioremediation and oil adsorption have both been accomplished by utilising thermal, physical, chemical, and biological methods, such as in-situ burning with the use of boom skimmers, dispersants, and surfactants. A widely used technique called in-situ burning uses direct oil burning to remove oil from the water surface. The burning produces harmful fumes and residues that damage marine life by sinking to the seafloor. Additionally, it is difficult to contain a fire's progress. The boom-skimmer technique involves two steps: containing oil spills using booms and transferring oil into a reservoir with the use of mechanical equipment known as skimmers. This technique calls for pricey speciality equipment. With some success, bacterial consortiums may be utilised for oil bioremediation. Oil is not always broken down by bacteria, and those that do are substrate-specific. There are a few straightforward and effective techniques for oil separation and spill cleanup. It is economical and environmentally good to remove oil from water surfaces using sorbents and sorbent devices. Numerous low-cost adsorbents have been thoroughly studied for oil adsorption, including biochar. Adsorbents for cleaning up oil-contaminated water should be buoyant, have a high affinity for various oil types, and be recoverable for long-term uses [4]–[6].

Alginate (Alg) may be derived from brown algae and seaweeds and is a naturally occurring substance. Because of the abundance of acidic carboxylate groups in it, it attracts water contaminants such as heavy metal ions, basic dyes, and medicines. However, recovering contaminant-loaded Alg hydrogel from the medium is challenging, which restricts the adsorbent's usefulness. Magnetite (Fe_3O_4), which is composed of magnetic iron, has been utilised to get around this restriction. To increase buoyancy, porosity, surface area, and thermal stability, diatomaceous earth (DE) was used to physically modify magnetic algae in this work. This was followed by hollow beads being shaped in an ionic crosslinking solution. According to information from a previous article, for buoyancy and stability, NaHCO3 and CaCO3 combine to generate interior chambers that are filled with magnetic beads. These characteristics make it easier to remove oil from water surfaces.

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The physicochemical characteristics of DE filler, such as its particle size, surface area, porosity, thermal stability, and acid resistance, were used. DE is an environmentally friendly adsorbent, sensor, catalyst, and drug delivery device. Although DE-based adsorbents successfully adsorb water contaminants, studies are difficult and adsorption information is hard to come by due to their sinkable nature and complex post-adsorption recovery. There are no published studies on the use of DE-based floating adsorbents to clean up oil-contaminated water. Magnetic beads with floating DE were used to test oil removal from water surfaces. To increase the beads' adsorption affinity towards different oil types on the surface of different water types, phthalic anhydride (PA) and maleic anhydride (MA) were chemically added to the attaching acid anhydride groups.

To assess the viability of oil clean-up using and, oil removal experiments were carried out by altering factors such as starting pH, contact time, initial oil concentration, oil type, and water type. Additionally investigated were kinetics, isotherms, recoverability, recyclability, floating stability, and magnetically driven characteristics. Different methodologies were used to assess the physical and chemical characteristics and that affect the effectiveness of clean-up. Effective, quick, and environmentally friendly oil-contaminated water cleanup was made possible by magnetic, buoyant, and recyclable beads.

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CHAPTER - 8

EDX MAPPING AND SEM ANALYSIS

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The micrographs demonstrate a significant disparity in the synthetic beads' cross-section and micro-surface construction. The Alg/Fe_3O_4 beads had spherical shapes and a rough surface, as shown in the surface microscopy. Fe_3O_4 attachment to the Alg matrix was confirmed by the widespread distribution of Fe_3O_4 microaggregates on the surface [1]–[3]. DE discs in the form of a sieve were seen.

Surface SEM micrograph and EDX-mapping of (a,b) Alg/Fe_3O_4, (c,d) Alg/DE/Fe_3O_4-MA, (e,f) Alg/DE/Fe3O4-PA, and cross-section SEM micrograph (inset: whole bead micrograph) and EDX-mapping of (g,h) Alg Alg/DE/Fe3O4-MA and Alg/DE/Fe_3O_4-PA possessed surfaces that were rougher (with numerous wrinkles) and had more pores than Alg/Fe_3O_4, which allowed for quick intra-bead diffusion. Alg/Fe_3O_4, Alg/DE/Fe_3O_4-MA, and Alg/DE/Fe_3O_4-PA cross-sectional micrographs all showed an oval-shaped cavity as a result of the interaction between acetic acid and $NaHCO_3$, a porogen found within the beads. After acetic vinegar dissolved the $NaHCO_3$ in the compound, $CaCO_3$ was added as an internal crosslinking agent to preserve the sphere's spherical shape. Alg formed a stiff structure by ionotropic gelation in response to Ca2+, a byproduct of $CaCO_3$ dissolution.

Complete ionotropic gelation was demonstrated by the distribution of Ca on the outer and inner surfaces of the synthetic beads. Fe_3O_4 was successfully trapped in the Alg matrix, as shown by the presence of Fe on both the outer and inner surfaces of Alg/Fe_3O_4, according to EDX mapping. Si, the main constituent of DE, was seen to be distributed in Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA, confirming the existence of DE in these materials. Si was detected at greater concentrations on the outer surface of Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA than on the inner surface as a result of CO2 production during $NaHCO_3$ and $CaCO_3$ dissolution.

Si was present in 23%–27% of Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA surfaces, which aided intra-bead diffusion. Al and K, two minor DE components, were also found in trace amounts (5%). The Alg/Fe3O4 surfaces lacked Si, Al, and K traces.

Physical Characteristics, Swelling, and Buoyancy

On DE entrapment and PA/MA attachment, it was discovered that Alg/DE/Fe_3O_4-PA and Alg/DE/Fe_3O_4-MA somewhat increased in size while maintaining their original shapes [4]–[6]. The swelling was brought on by water molecules entering the gel bead matrix via DE pores. Following MA/PA alteration, the hydrophilicity of the bead surface reduced, resulting in less water entering the gel matrix and a lower swelling ratio. Both Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA beads floated in demineralized water, tap water, and saltwater and kept their buoyancy for up to 30 days because of their spherical form. As a result, there was considerable interaction between the water's surface oils and Alg/DE/Fe_3O_4-MA or Alg/DE/Fe_3O_4-PA.

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XRD Evaluation

A Digital calliper was used to measure the average bead size (n = 100). SiO_2 had two peaks, one sharp at 28.20 and the other wide and centred at 22.14. Quartz crystals are often seen in DE. Only peaks related to Fe_3O_4 were found in the diffractogram when Fe_3O_4 and DE were co-entrapped in Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA. When Fe_3O_4 is trapped in other materials, this effect is seen. According to SEM examination, the distribution of crystalline Fe_3O_4 on the surfaces of Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA may be the cause of this. By using EDX mapping, it was determined that the amount of entrapped Fe_3O_4 was larger in Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA than DE. Due to Fe3O4's strong thermal stability, no breakdown was seen over the whole temperature range that was investigated. Contrarily, multistage deterioration was seen in the thermograms of the naked Alg beads and the composite beads, with Tmax values of 205.65, 273.05, and 737.37 C, respectively, indicating multi-step disintegration.

Physically bonded water molecules are released in conjunction with the mass breakdown at temperatures below 200 °C. Bare Alg beads and Alg/Fe_3O_4 showed 9% and 7.78% mass losses, respectively, in the first stage (below 200 °C), while Alg/DE/Fe_3O_4, Alg/DE/Fe_3O_4-MA, and Alg/DE/Fe3O4-PA lost less than 5% of their masses. 38.32% of the bare Alg beads deteriorated at Tmax (273.05 °C) by polysaccharide ring breaking in the second degradation stage (200-350 °C), which was brought on by the burning of organic material (Metin et al., 2020). Alg/DE/Fe_3O_4 and Alg/Fe3O4 on the other hand, showed 14.52% and 12.24% mass losses, respectively, demonstrating that the addition of Fe_3O_4 and DE to the Alg matrix reduced thermal instability and slowed down decomposition. The combustion of the Alg matrix and the MA/PA groups resulted in a 14% mass loss for both Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA. As an inorganic byproduct of the carbonization process, 26.22% of the bare Alg bead mass was maintained in the final stage, but the residual masses of Alg/Fe_3O_4, Alg/DE/Fe3O4, Alg/DE/Fe_3O_4-MA, and Alg/DE/Fe_3O_4-PA were 66.24%, 72.71%, 64.86%, and 6. This showed that the addition of Fe3O4, DE, MA, and PA increased the thermal stability of Alg beads by a factor of more than 2.4. The quantity of MA and PA attached to the surface of Alg/DE/Fe_3O_4-MA and Alg/DE/Fe_3O_4-PA, respectively, was determined to be 7.85% and 8.69% by comparing their residual masses to that of Alg/DE/Fe_3O_4.

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CHAPTER - 9

BENTONITE AND DIATOMITE EFFECTS

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When the high-filter-loss-squeeze slurry's composition was originally investigated, it was found to be composed of bentonite and diatomite. The high fine solid content of the diatomite may serve as a filter aid material to help create a long-lasting seal of the permeable formation. According to, bentonite expands significantly when exposed to water, making it the perfect material for shielding underground formations from drilling fluid entry. Bentonite is often added to mud to increase viscosity [1]–[3].

The quickest total loss of filtrate occurred when 20 ppb diatomite was used without the addition of bentonite. The length of time grows as the number of bentonite increases. Utilizing solely diatomite at concentrations of 80, 60, 40, and 20 ppb, the filter cake thickness was 13.3, 10.7, 7.4, and 3.6 mm shows photos taken with a scanning electron microscope of several distinctive diatoms found at various locations around Qasr El-Sagha. Epithemia turgida, a view of the valve face from the outside (scale bar: 10 lm). The strong internal costae are seen in the interior view of the valve face in (b) (scale bar = 10 lm). Epithemia sorex (c-e). Scale bar: 10 lm. Internal views of the valve are shown in (c and d) with thickened internal costae. A magnified image of a portion of the valve (scale bar: 2 lm).

Cake thickness grew as a result of the sample losing all of its filtrate, which led to all of its solid components precipitating and increasing the filter cake's thickness. Diatomite's ability to act as a filter aid was inhibited by the bentonite's high concentration. The cake in the other concentrations exhibited many fractures, indicating that it would not securely cover the fracture in the reservoir during drilling. As a result, the optimal concentration of diatomite was 40 ppb [4]–[6].

According to Kilchrist and Verret, the concentration of diatomite used in the HAC (Hardenable alkaline composition should ideally be in the range of around 22.5 to about 50 percent by weight, with a preference for at least 22.5 percent. A particularly favoured range is between 24% and 35% by weight. The outcomes of this experiment demonstrated that bentonite addition had a passive impact on high filter loss squeeze slurry, particularly when its concentration was increased on both the time for filter loss and mud cake thickness.

Lime's Impact

If sodium silicate is present, it is thought that lime will react with it to generate calcium silicate and sulphate. The cake's compressive strength is increased as a result. Without adding any bentonite, lime was applied to the diatomite. The ideal level of lime may be anywhere from 15 and 20 ppb, with 15 ppb being the optimal level. For both 15 and 20 ppb of lime, the complete filtrate losses took place during 1:50 min. The chosen lime concentration was 15 ppb since the mud cake's thickness was 9.2 mm for a lime concentration of 15 ppb and 8 mm for a lime concentration of 20 ppb, respectively. Lime may vary in weight percentage from 9 to 50. The greatest outcomes with a lime range from about 24 to about 35 weight percent of the combination, while better results with a lime range from about 22.5 to about 35 weight percent.

Agriculture waste was used because it was thought to be a local, affordable resource that served the purpose of fibrous materials. Hay is now being employed for the first time as a fibrous component in drilling fluid in general; it is not included in high-bit error squeeze slurry. As part of the process of creating the filer cake, hay creates a mat over the crack to minimise its size. Numerous writers used agricultural waste products, such as rice straw, sugarcane bagasse, sawdust, cotton stalls, orange mesocarp, weeds, and Eichoria crassipes.

In the current investigation, various hay concentrations were tried to see whether they might improve the characteristics of high-filter loss squeeze slurry. Three ppb was the optimal concentration. In 1:36 minutes, the filter cake's thickness was raised to 13.5 mm. More than 3 ppb of hay allows it to float on the water's surface while affecting the structure of the cake. The filter cake's homogeneity was remained subpar despite shorter processing times and thicker cakes. To improve the uniformity of the filter cake, it was crucial to add another fibrous material.

Paper's Impact

The fluid in aqueous slurries was suspended using finely split paper. Between 3 and 7.5 ppb is the recommended quantity of paper to offer outstanding suspending action without unnecessarily raising viscosity or unnecessarily limiting water loss by 5 ppb. Paper was combined with the aqueous phase to create a paper pulp that served as a suspending material, improving the uniformity of the filter cake the quantity of paper used to stabilise the slurry is at least 2% by weight of the HAC (Hardenable alkaline composition) composition. The percentage of paper might vary from 2 to 30 percent of the total weight. The optimum amount is between 90% and 13% by weight to give good suspending. A desirable range is between about 3.5 and approximately 15.5 percent by weight.

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CHAPTER - 10

OIL AND GAS WELL COMPLETION FLUID FILTRATION

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Oil firms need to get the most output out of each well since global oil and gas supplies are depleting and alternative energy sources are becoming more prevalent. It is essential to minimise production costs, maximise hydrocarbon recovery, and prolong reservoir life as much as feasible in addition to maximising hydrocarbon output in a manner that is safe for the environment and people. In order for oil and gas wells to be productive, completion fluids are essential. Utilizing completion fluids makes it easier to complete tasks before production begins, may boost well capacity, reduces difficulties with good maintenance, and makes it easier to clean and shut down the well when the time is appropriate [1]–[3].

Finishing Fluids

Theoretically, completion fluids might be any fluid with the right density and flow properties for the task. However, completion fluids also referred to as well bore clean out fluids and workover fluids are often specifically produced brines concentrated salt solutions. Chlorides, bromides, and formats are used in their formulation, which is done by specialist chemical makers for the task at hand a class of salts made from the neutralisation of formic acid.

Chemical compatibility between the reservoir formation and the completion fluid is necessary a general term for the rock around the borehole. The life of the good production zone may be extended by matching the density, flow, and pH content to the particulars of the well. The formulation, production, and selection of the ideal completion fluid for a given well need competence. Fluids may be purchased ready for use or produced to order to satisfy particular requirements. It is a common misconception in the oil and gas business that a custom-made completion fluid, although initially more expensive, would ultimately save money and enhance output throughout the well's production life. Filtration is an efficient way to ensure that finishing fluids are clean and solids-free, which will increase their usable life and efficiency [4]–[6].

Reasons to Filter Completion Fluids

An effectively filtered and fully solid-free completion fluid will increase a well's productivity and reliability over the long haul. Solids and contaminants in the completion fluid will limit its efficacy. Filtration produces clean fluids that guard against harm to the formation, reservoir, and fluid transmission capabilities (its permeability or measurement of the formation's ability to transmit fluids). This is accomplished by filtering out sediments and particles from the fluid that may otherwise obstruct the porosity, or open spaces, inside the rock formation that contains the hydrocarbon fluid in the production zone.

Filtration of a finishing fluid is required when initial drilling fluid displacement is a liquid that is used to push another fluid or cement slurry into the annulus, the region outside the good drill casing wash both before and after perforation a cleaning procedure used to ensure effective

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"communication" between the reservoir and the wellbore after holes (perforations) are formed in the well bore casing or liner.

In the gravel packing process

This is a control strategy used to stop the formation of sand generation. The main goal is to stabilise the formation with the least possible impact on good production. When drilling out of cement during under-reaming processes used to make a wellbore larger than it was when it was first drilled or during maintenance operations final inhibitors and additives move around.

Chemicals are added to fluids to delay or stop undesired reactions from happening to the fluid itself or other substances in the environment and flow through the well an activity that involves pumping fluid across the whole active well bore and surface fluid system for trip displacement, pill quantities, and pill spotting, filtered fluid [7]–[9]. At several points during the drilling and well-completion process, specialised fluids are employed to complete particular tasks. These operations are used to release a differentially stuck drill pipe, dissolve invasive salt deposits, eliminate caking and coating, reduce differential sticking forces, and raise cuttings out of a vertical wellbore.

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CHAPTER - 11

FILTRATION REQUIREMENTS FOR COMPLETION FLUIDS

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Due to the complex nature of the process and the solids/debris that the fluid encounters during its production cycle, the requirements for filtering finishing fluids are stringent. The main issues to take into account while establishing a completion fluid filtering system are as follows: Typically, the filtration should remove particles with an absolute efficiency of better than Beta5000 (a filtration efficiency of 99.98% removal of solids at the micron rating of the system), depending on the formation and well borehole requirements .

1. The system should generate filtered fluid with low suspended solids of between 50 NTU and 10 NTU (Nephelometric Turbidity Units a system for the measurement of suspended particulates in a liquid or gas colloid).
2. It needs to be able to handle flows of up to 4 to 35 BPM (Barrels Per Minute).
3. It is advisable to eliminate solid particulates in a variety of sizes.
4. Before installation, the system's operating capabilities and integrity should be verified offshore.
5. The filtering system should be capable of handling extremely high dirt loads up to 1%, which are often present in finishing fluids.
6. Fluids have a natural flow resistance due to their Specific Gravity (SG) up to 22PPG (pounds-per-gallon), for which the filtration system must be built.
7. The filtration system has to be straightforward and strong enough to withstand the installation's challenging operating and climatic circumstances.
8. Above all, it must be affordable to operate and maintain.

Best Practice for Filtration

The filtering system must be able to handle the variety of completion fluids that are utilised during the life of an oil or gas well, each having unique properties. A good completion fluid filtering system must be built to manage high flow rates and quick throughputs when the well is operating, as well as a reasonably high amount of particles in a variety of particle sizes. For the filtration of finishing fluids, a variety of filtration methods are accessible. These consist of:

1. Cartridge filtering using dual vessel cartridge filter units
2. Bag/cartridge dual-vessel filter units
3. Vertical Pressure Leaf Filters (VPL) with Dual Vessel Cartridge Filters and Filter Press (FP) with Slurry Mixing Skid [1]–[3].
4. Technology for Filter Press (FP) Systems Filtration of completion fluids using Filter Press (FP) systems has been standard practise in the oil and gas industry for many years.

A typical Dutch filtering system is 1200 square feet. A set of sealed filter plates with a permeable filter cloth within are used in FP systems. A hydraulic cylinder secures all of the plates in a vertical configuration. The filter cake (DE-media) and the dirt particles are held in filtering chambers that are created by all of the plates.

Filter Press-Dutchfiltration

A typical twin slurry mixing skid for Dutch Filtration. A slurry mixing skid is included with FP systems to mix and add the filter aid known as Diatomaceous Earth (DE). An air-driven diaphragm pump for pre-coating and body feed for the DE is installed on the slurry skid. There are two mix tanks (16 BBL each) in this unit. This configuration of the FP and Slurry Skid, together with a Dual Vessel cartridge filter unit downstream, offers the most dependable method for filtering out heavy finishing fluids at up to 35 BPM. An example of a Dutch VPL filtering system. The vertical pressure leaves (VPL) used in VPL systems are composed of self-supporting stainless steel mesh and are coated with robust polypropylene fabric. An air-driven diaphragm pump is used to supply filter aid via a mixing tank for the pre-coating and body-feed of the diatomaceous earth. A Dual Vessel Cartridge Filter that employs glass fibre absolute pleated cartridges polishes the fluid one last time. For the filtration of completion fluids, this system offers a very effective and dependable option.

Vertical Leaf Filters under Pressure

Filtration Using Diatomaceous Earth

Diatomaceous Earth [DE] is a naturally occurring, siliceous sedimentary rock made from the preserved skeletons of tiny hard-shelled algae called diatoms. Their average particle size is between 10 and 200 microns, although they may range from less than 1 micron to more than 1 millimetre. To increase filtration effectiveness and lengthen the life of the filtration system, diatomaceous earth is utilised as a filter aid. Diatomaceous Earth, a filter aid, is added to both FP and VPL systems before starting a filtering duty. The filter aid is then cycled through the system until a filter cake forms on the surface of either the FP filter media or the stainless steel mesh grid of the VPL filter.

Diatomaceous Earth Filtration Principles

The pre-coat and body-coat stages are often used to accomplish this. This pre-coat and body feed combination makes sure that the DE filter cake stays porous and does its job as a filter. The cake of DE effectively serves as the optimum filtering medium for the removal of huge volumes of solids because it has a non-compressible microporous structure.

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CHAPTER - 12

USING A FILTER PRESS

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Diatomaceous Earth (DE) filter aid must be pre-coated on the Press filter unit before filthy fluid filtering can begin. DE is continually added while the filthy brines are being filtered body feed. Within a component known as the slurry mixing skid, the DE is kept in a stainless steel tank with an air agitator for homogenous mixing. It is then pumped back to the mixing unit from the FP unit using an air-driven diaphragm pump, where it is gradually withdrawn from the fluid flow until a cake forms as a pre-coat on the filter cloth within the FP unit. This method is often referred to as precoating. Once the DE pre-coat layer has formed, the filthy fluid is delivered to the system along with another low dosage of DE known as the body feed. The DE body feed prolongs the life of the filtering cycles by keeping the filter cake porous [1]–[3].

Solutions with Smaller Footprints

Cause of the filter presses and the mixing slurry skid's enormous footprints. The footprints of the filter spread are greatly reduced when the specially designed collapsible mixing skid with a twin cartridge filter is put on top of the filter press. It is possible to operate securely on top of the filter press with its stackable design. We should add DE media and replace our cartridges. Dual cartridge filter unit with stackable slurry skid filter press

Operation of Vertical Pressure Leaf Filters (VPL)

Similar to the FP filter, the VPL filter unit needs a Diatomaceous Earth [DE] pre-coat and body coat before it can perform its filtering function. For continuous operation, two Vertical Pressure Leaf Units are installed side by side. The DE is first kept in a combination tank where it is agitated by compressed air. It is then cycled through the Vertical Pressure Leaf filter vessel, where the DE is gradually eliminated from the fluid flow until a cake forms as a pre-coat on the surfaces of the filter leaves (stainless steel leaves with polypropylene filter cloth). The unclean brines may be poured into the filter once the pre-coat layer of DE has formed on the surface pressure filter leaves and a small continuous dosage of DE, known as the body feed, is delivered to the system. The best filtering solution for the removal of large amounts of solids is this pre-coat and body-coat combination. Due to its ability to handle the rigours of high-speed processing where con body-continuity of filtering is crucial, the VPL/DE and Dual Vessel Filter system is a suitable choice for high flow rate and throughput applications.

Vertical Pressure Leaf (VPL)

Over time, as particles are removed by the VPL filter and the differential pressure [dP] increases throughout the filter system, the flow rate decreases. When the fluid flow eventually decreases, the filter must be sterilized (wash down) [4]–[6].

The VPL system's benefit is that cleaning may be done semi-automatically using a high-pressure water wash-down system to clean the vertical pressure leaves. A fresh pre-coat of DE

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will be applied after disposing of the used DE and the removed particles via the dump line. The next step takes around 15 minutes, after which the VPL filter is put back into operation.

Filter Press vs. Vertical Pressure Leaf

Every filtering system has a specific use in a certain line of activity. The length of a filter cycle, considering the pressure differential and cleaning time, is crucial. When comparing Vertical Pressure Leaf (VPL) DE with traditional Filter Press plate (FP) systems of the same size unit, the VPL/DE system has a vast 90% effective flow area accessible for filtering tasks whereas the FP system has a less effective flow area. This is because the leaves in the VPL filter have a strong, self-supporting structure, while the FP system requires close support from the filtering medium. This is why VPL is 600 square feet, although the most popular filter press size is 1200 square feet.

The filter press, which has a surface area of 1200 square feet and a cake capacity of 1500 litres, is the industry standard and can process almost all fluids. A filter press can run up to a maximum difference of 7 bars, however, a VPL can only clean at a maximum of 4 bar dP. Filter cake releases from the filter press more easily the denser the filter cake is. Filter presses are often used for heavier fluids, whereas VPL are typically used for light brines and tiny footprints.

System for Dual Vessel Cartridge Filtration

The most typical filter system seen at an oil drilling site or mud facility is a twin cartridge filter system. Always used after a filter press or vertical pressure leaf to polish the fluid. Typically, a 2 or 5-micron filter cartridge is used for this. However, due to its excellent versatility and compact size, the twin cartridge filter unit is often the sole one utilised for modest volumes of fluids. These twin pod devices have a filtering range of a few millimetres to 0.5 microns and may be used with filter bags or cartridges. The user is always given the option to choose the most cost-effective solution for a certain filter task thanks to the availability of many filter components. Continuous filtering is possible with the two parallel filter housings. Alternatively put, filtering over one housing and a change in the second housing's components. The 6-valve manifold provides flexibility for the rapid switchover, bypass usage, or even series use of both filter vessels.

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