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Aliagha Shukurlu
Azerbaijan State Oil and Industry University
master student
aliaghashukurlu@outlook.com

PREVENTING FORMATION DAMAGE AND OPTIMIZING PRODUCTION RATES IN THE OIL AND GAS INDUSTRY: A STUDY ON THE EFFECTIVENESS OF NON-INVASIVE FLUIDS AND MIXED METAL HYDROXIDES IN CONTROLLING FLUID LOSS DURING DRILLING OPERATIONS

Abstract

Severe lost circulation during drilling can cause formation damage and reduce hydrocarbon production. Special drilling fluids like NIF and MMH are effective at preventing damage due to their high control over fluid loss and compatible chemical structure. These fluids can efficiently bridge and seal loss zones, are easily removable, and result in high permeability recovery of the formation. Their use can optimize production rates in the oil and gas industry.

Keywords: *hydrocarbon, bridge, formation damage, optimize, recovery*

Əliağa Şükürlü
Azərbaycan Dövlət Neft və Sənaye Universiteti
magistrant
aliaghashukurlu@outlook.com

Neft və qaz sənayəsində formasiyon zərərlərinin qarşisinin alinmasi və hesabat hərçələrinin optimal edilməsi: Maye itkilinə nəzarət etməkdə qeyri-invaziv mayelər və qarışıq metal hidroksidlərinin səfərliliyinin tədqiqi

Xülasə

Neft-qaz sənayesində qazma prosesi zamanı dövriyyənin itirilməsi hadisəsi baş verə bilər. Bu, qazma mayesi laya axdıqda və səthə qayıtmadıqda baş verir. Bu, laylara ciddi ziyan vura və karbohidrogen istehsalını azalda bilər. Bu problemi həll etmək üçün NIF (Qeyri-invaziv Maye) və MMH (Mikronize Mika Hematit) kimi xüsusi qazma mayeləri hazırlanmışdır. Bu mayelər maye itkisi üzərində yüksək nəzarət və layla uyğun kimyəvi quruluşa görə itkin dövriyyənin qarşısını almaqda təsirli olur. Bu mayelərdən istifadə edildikdə, onlar təsirli şəkildə itki zonalarını möhürləyə və nəticədə layda maye itkisinin qarşısını ala bilərlər. Bundan əlavə, bu mayelər asanlıqla çıxarılır və lay qazmadan sonra öz keçiriciliyini tez bir zamanda bərpa edə bilir. Bu xüsusi qazma məhlullarından istifadə etməklə, neft və qaz sənayesində istehsal tendensiyasını optimallaşdırmaq mümkündür.

Açar sözlər: *karbohidrogen, körpü, lay zədələnməsi, optimallaşdırma, bərpa*

Introduction

Oil companies compete to explore, drill, and produce petroleum due to the increasing need for energy. Understanding the mechanisms that damage hydrocarbon reservoirs is crucial for maximizing production efficiency (Ela Ma, 2013: 67). Operations such as exploratory, developmental, descriptive, and repair are analyzed to assess the extent of damage to wells. Fractured reservoirs pose additional challenges, with high-pressure and low-pressure parts that complicate operations (Nasiri, Ghaffarkhah, 2017: 6).

Studies in 2017 used the GustafsonKessel method to model fluid loss, analyzed experimental and field analysis to control drilling fluid loss, and estimated sectors with critical loss using the index kriging method (Shad, 2021: 32). Another study in 2020 examined the effect of bentonite

mud contents on fluid loss, and a 2021 study found that dynamic fluid loss decreased with increasing overbalanced pressure due to the formation of mud cake on the well wall. (Taheri, Anseri, 2021: 3).

Objectives

1. To identify the most effective materials for preventing formation damage caused by lost circulation during drilling operations.
2. To analyze the physical and chemical damage caused by the loss of drilling fluid and the impact on the permeability of the formation.
3. To assess the effectiveness of anti-loss materials in preventing formation damage and optimizing production rates in the oil and gas industry.
4. To provide recommendations for prevention and treatment methods to minimize formation damage during drilling operations.

Formation damage in hydrocarbon reservoirs

Oil companies face frequent issues of hydrocarbon formation damage that reduces well productivity due to decreased permeability caused by various factors. Mr. Civan identified seven mechanisms of damage to hydrocarbon reservoirs in 2006, summarized in Table 1. (Shu, Yan, 2008: 327).

Table 1. Assessing the potential risks associated with formations in various operations.

Significance (%)	Damage Removal (1-5)	Total Formation Damage (%)	Operation
75	2	25	Drilling
65	3	25	Well Completion
65	4	15	Stimulation
45	3	15	Production
40	4	10	Internal factors of wells
20	2	10	Injection

a) Emulsion formation between oil-based mud filtrate and water formation due to fluid incompatibility.

b) Permeability reduction due to rock-fluid incompatibility, swelling and nodules of smectite and kaolinite clays with water.

c) Invasion of solid particles, such as weight gain particles or drilling cuttings.

d) Entrapment or blockage due to invasion of water-based mud around gas well wells.

e) Permeability alterations and chemical adsorption caused by emulsifier adsorption and changes in fluid flow characteristics in the formation.

f) Fine particle migration within rock pores causing pore throat plugging and bridging.

g) Biological activities from the entry of bacteria during drilling and production of polysaccharide polymer strips, leading to permeability reduction.

Methods

During drilling operations, drilling mud is used to prevent fluid blowouts. However, the use of drilling mud can also cause damage to the formation through mud filtrate invasions, invasion of external solid particles, and water sensitivity. Drilling mud filtrate invasions occur when drilling fluid penetrates the formation, but the mud cake formation reduces the amount of filtrate penetration, which can reduce the permeability and wettability of the formation. Invasion of external solid particles can also cause damage to the formation by invading the pores within it. This damage includes flow restriction and plugging. (Figure 1.)

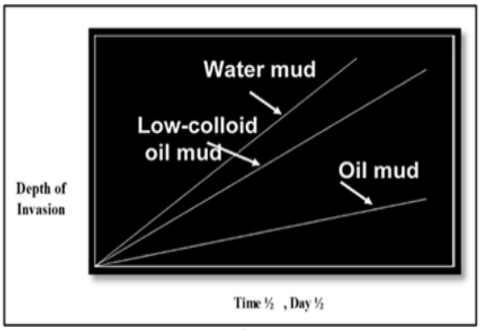

Figure 1.: Filtrate penetration in different muds

Water sensitivity can occur when mud filtrate causes clay swelling in the formation, which reduces permeability by blocking pores and throats. This is particularly problematic with smectite clay, which can swell up to 600%, creating an almost impermeable barrier to flow. (Figure 2.)

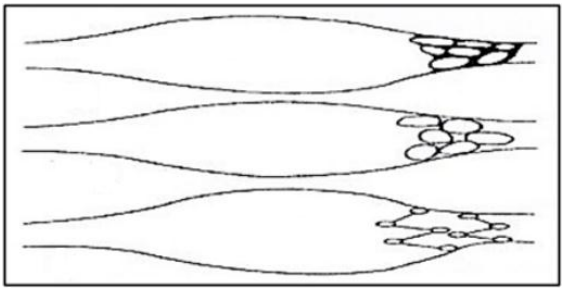

Figure 2. Fine particle migration and throat damage mechanisms.

To prevent damage to the productive layers and decreased productivity, strategies such as using Non-Invasive Fluid (NIF) and low-damage Mixed Metal Hydroxide (MMH) can be employed.

These methods have been tested and proven to produce good results. The ideal drilling fluid for oil reservoirs should bridge the throat cavity without changing its formulation, quickly and without damaging the formation. It should also handle high overbalance tasks and be effective across

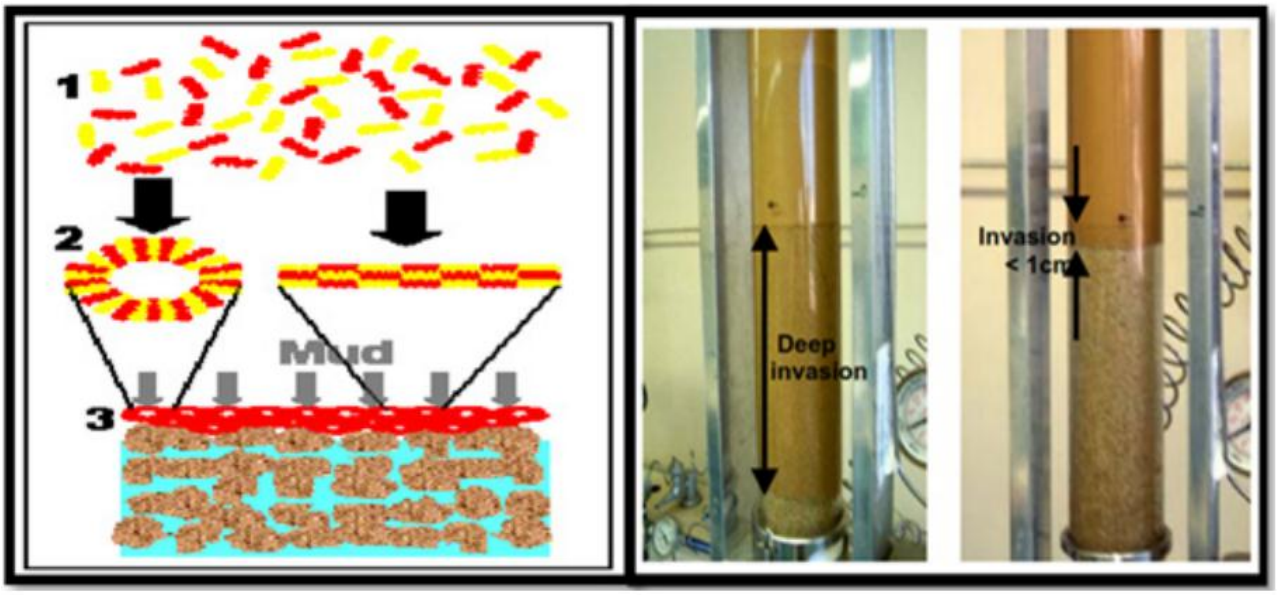

Figure 3. On the left, there is a significant penetration of oil-based mud into a layer of sandstone, while on the right, the mud containing micelle additives (NIF) at a concentration of 5ppb only exhibits invasion of less than 1cm.

different ranges of density, temperature, and bottom well pressures. Preparation should be easy and any additives used should be non-toxic and HSE-approved. The NIF is a laboratory-tested drilling fluid that meets specific criteria before being used in field operations. NIF is a water-based polymer fluid that forms micelles with water- and oil-soluble polymers.

It can form a low-permeable surface to prevent further invasion, reducing damage to layers and boosting productivity during drilling.

Conclusion

Special drilling fluids like NIF and MMH can effectively address lost circulation in fractured and depleted reservoirs, which are more prone to experiencing loss due to reduced pressure during production.

These fluids are compatible with formation fluids, reduce loss significantly, and lead to high permeability recovery. Using these fluids can increase recovery efficiency and play a vital role in achieving important goals in the oil and gas industry.

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