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An overview of techniques to improve heavy Crude oil recovery

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Abstract

There are three stages in the production of oil: secondary, primary, and tertiary. First, the extraction of hydrocarbons that naturally rise to the surface is the primary recovery step. The second phase begins with the injection of gas and water into the well to bring oil to the surface. The well still contains 60–80 percent oil after the second phase is completed. Accordingly, the execution of improved oil recuperation (EOR) during the last stage, which is the tertiary stage can contribute up to 30% of unique oil set up (OOIP) that can be removed. Consequently, EOR can be represented by a few methods, including chemical injection, thermal recovery, nanoparticle technology, and carbon dioxide injection.

Introduction

Heavy oils have a viscosity greater than 100 cP and an American Petroleum Institute (API) gravity between 10 and 20 API. They are asphaltic, dense, and viscous. The increased viscosity and density of these crude oils necessitate greater energy demands for production and transportation [1,2]. It is anticipated that heavy oil recovery will make a significant contribution to resource and energy conservation, as well as environmental protection.

Nanotechnology is one of the methods that is getting a lot of attention right now to improve oil recovery because it is cheap and good for the environment [3]. For oil recovery, nanoparticles typically range in size from 1 to 100 nm. The size may somewhat vary from some other worldwide association. First and foremost, the metallic oxide nanoparticles that explain the nature of the metal element demonstrate that it is a reactive and unstable element due to its low electronegativity and low ionization potential. When it comes into contact with oxygen or reacts with it, the metal element can quickly lose an electron and enter a stable state. Aluminum oxide, copper(II) oxide, iron oxide, nickel oxide, magnesium oxide, tin oxide, titanium oxide, and zinc oxide are a few examples of metal oxide nanoparticles that have recently been studied.

The interfacial tension (IFT) is the most important factor when using nanoparticles to improve oil recovery (EOR). The oil recovery improves as a result of this parameter's contribution to lowering the capillary force. A few investigations show that IFT decrease between the oil and fluid stage when blended in with nanofluids increment oil recuperations [4]. As the IFT between the oil and aqueous phases decreased, the trapped oil droplets may have deformed, making it easier for them to pass through the pores . The wettability, which is determined by the intricate interface boundary conditions operating within the pore space of sedimentary rocks, is another parameter [9, 10]. If nanoparticles are absorbed on the grain surface, the wettability change occurs. Aluminum oxide (Al_2O_3) nanofluid is the most highly regarded metal oxide nanoparticle for use as an oil recovery agent in heavy oil reservoirs. The oil-brine IFT and oil viscosity might go down as a result. When Al_2O_3 nanoparticles are dispersed in diesel, spontaneous imbibition recovery in sandstone cores is highest [5]. Other than that, an examination directed by specialists found that Al_2O_3 nanoparticles can de-balance out water drops which lessen the water in oil emulsion. This case shows that Al_2O_3 might diminish the emulsion thickness. However, it concludes that pore throats can be blocked by a higher concentration of nanoparticles due to the aggregation of particles around the pores, which may prevent oil recovery. This demonstrates that the Alomair et al. study the least grouping of 38.5% of oil recuperation is acquired because of the IFT decrease and emulsion consistency. Iron oxide particles can reduce the viscosity of crude oil due to its unique magnetism and low toxicity. In sandstone reservoirs, iron oxide can be a useful oil recovery agent because it spreads in brine. For unprompted imbibition in sandstone rocks, it shows that when diesel is chosen as a scattering specialist, iron oxide can go about as a superior oil recuperation up-and-comer with cases of 82.5% of all out oil recuperation. Iron oxide has been used experimentally to coat polymer during oil and water separation [6]. Polyvinylpyrrolidone (PVP) is the polymer utilized and covered with this nanoparticle, and results in close 100 percent of oil recuperation because of the PVP that tends to retain both aliphatic and fragrant parts of oil part, and the iron oxide goes about as an underlying scaffolding which permits attractive detachment from watery stage without any problem.

Inorganic nanoparticles, the unmistakable component utilized is silica. The SiO2 nanoparticles that Gogolo et al. have proposed shows that the use of this kind of nanoparticle in water-wet sandstone reservoirs makes SiO_2 a good EOR agent for this kind of rock. According to research, SiO_2 powders' specific surface area almost does not change when heated to temperatures up to 65°C, demonstrating good thermal stability. By forming a more stable emulsion in 3%wt NaCl brine and achieving a higher oil-brine IFT than a mixture of brine and stabilizer on its own, it also does not require a stabilizer in comparison to metal oxide, which increases oil recovery from Berea sandstone.

Scientists examine that SiO_2 nanoparticles on the air pocket surface improve the froth solidness against film crack and Ostwald maturing. Due to larger bubbles being flushed and compressed into smaller bubbles toward the dead-end, the bubbles are more stable than foam when they meet the residual oil. The steadier air pockets enter further inside the pore which can dislodge more oil. The microforces acting on the oil droplet also aid in the recovery of additional oil when the stable

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bubbles enter the dead-end pore. The foam is protected from Ostwald ripening because the attached nanoparticles on the bubbles reduce the surface area available for interbubble gas diffusion. Aside from that, SiO2 nanoparticles are still considered a suitable EOR agent in all wettability conditions, from water-wet to intermediate and oil-wet, even though their use in core-floods conducted at room temperature results in less recovery. The researchers explain that coating the SiO2 nanoparticles with alumina completely alters their properties.

A positive charge is created on the surface of a nanoparticle by the coating. The study demonstrates that SiO2-coated alumina has a greater surface area than uncoated alumina and is less toxic when disposed of in the environment. The concentrate likewise emerges with entrancing outcomes in which alumina covered silica nanoparticles with changed surface structure a more steady froth and result in great oil recuperation from sandstone centers contrasted with the uncovered nanoparticle or any surfactant flooding [7]. The addition of a silanol (Si-OH) group to the surface of hydrophobic silicon oxide nanoparticles yields satisfactory results, demonstrating that it is a superior EOR agent in thesandstonereservoirtometaloxidenanoparticles. Aluminum oxide (Al2O3) nanofluid—The majority of the time, nanoparticles are used in the enhancing oil recovery (EOR) process. Oil brine interfacial tension (IFT) is decreased by Al_2O_3. With distilled water acting as the dispersing agent, the total recovery is 12.5%. 5.0% of the total recovery is attributable to nanoparticles (brine as a dispersing agent). Al_2O_3 diminishes oil consistency Possesses a distinct magnetism property. Can lower the viscosity of oil. The total recovery is 9.2%, with distilled water serving as the dispersing agent. Diesel as a scattering specialist came to 82.5% of oil recuperation.

Al_2O_3-like properties are shared by nickel oxide (Ni_2O_3) Nanoparticles (distilled water as the dispersing agent) account for 2.0% of the total recovery. Absolute recuperation due to nanoparticles (salt water as scattering specialist) is 1.7%. The oil recovery was as high as 85 percent. Sandstone rocks' permeability is affected by magnesium oxide (MgO). Lessen oil consistency while splashing the stone example in ethanol with MgO. Complete recuperation due to nanoparticles (refined water as scattering specialist) is 1.7%. Zinc oxide (ZnO) has very little application in EOR. These nanoparticles have the potential to obstruct the pores, which has negative effects. Absolute recuperation due to nanoparticles (refined water as scattering specialist) is 3.3%.

- Zirconium oxide (ZrO_2) is a rare material utilized in EOR.
- Demonstrate a modest oil recovery when compared to distilled water alone.
- Nanoparticles (distilled water as the dispersing agent) account for 4.2% of the total recovery.
- Tin oxide (SnO_2) shares many of the same properties as zirconium oxide.
- Spreads more evenly in distilled water, increasing oil recovery.
- Nanoparticles (distilled water as the dispersing agent) account for 3.3% of the total recovery.
- Recover 80% of the oil from oil-wet Berea sandstone using titanium dioxide (TiO_2)
- Lower the IFT of the oil brine.
- Outperformed SiO_2 in terms of oil recovery in wet formations.
- Multiwall carbon nanotubes (MWNT)
- Nonappearance of electromagnetic (EM) wave shows 36% of oil recuperation.
- 72% of recoveries are accompanied by EM waves.
- Lower oil recovery at room temperature with SiO_2.
- Considered to be an appropriate EOR agent under all wettability conditions.
- Stable bubbles penetrate further into the pore, displacing more oil, resulting in stable foam.

Hydrophobic silicon oxide (SiO_2)

In an EOR process, the risk of blocking the pore is reduced by the small size of these particles, which range from a few nanometres to tens of nanometres [8].

Nano composite with a polymer-shell core or inorganic silica. Improving viscosity at critical concentrations .When dissolved in ethanol, it can be an excellent EOR agent for sandstone reservoirs. Lower oil recovery at room temperature with SiO_2. Considered to be an appropriate EOR agent under all wettability conditions. Stable bubbles penetrate further into the pore, displacing more oil, resulting in stable foam. Hydrophobic silicon oxide (SiO_2) [9]. In an EOR process, the risk of blocking the pore is reduced by the small size of these particles, which range from a few nanometers to tens of nanometers. Nanocompositwith a polymer-shell core or inorganic silica . Improving viscosity at critical concentrations .When dissolved in ethanol, it can be an excellent EOR agent for sandstone reservoirs.

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