PETROLEUM ENGINNERING

Table of Contents

Introduction

1.1 Study background

Enhanced Oil Recovery is an innovative topic in the field of Petroleum Engineering. There are different methods available for the recovery of the oils in the most effective ways while the flooding of the oils with gas like Carbon-di-oxide is the method that is widely used in the organizations and the industries; however there are some evident drawbacks of the process. The usage of the chemically active foam is the method, which is a growing prospective of the industry and promises to overcome the imminent and existent drawbacks of the presently used processes. The CAF provides an opportunity to manage the mobility of the oils, which improves the volumetric sweep efficiency. The Alkaline-Surfactant-Foaming method exhibits some problems like the formation of carbonic acid when dissolved in water; this carbonic acid is potent enough to corrode the steel containers that are used in the industry, fir the purpose. This project aims to study the benefits and the interim methods of chemically active foam (CAF) flooding, without the usage of alkaline components in the ASF methods for the oil recovery.

1.2 Rationale

Enhanced Oil recovery is a term that is used to describe the techniques that are implemented in the industries, for increasing the amounts of the oil that is recovered from the oil fields and the underground crude oil reserves. The EOR methods are referred to as tertiary recovery methods, the water and the gas flooding methods being the primary and the secondary methods. The primary recovery technique relies on the pressures occurring within the oil reservoirs and coerces the oil to the exterior facade for the mining. This process leaves around 92%-95% of the oil unrecovered. The secondary techniques utilize flooding the oil reserves with water and gas, for the collection of the crude oil. This process is successful than the primary techniques, though almost 75% of the oil in the reserves stays unrecovered. With the advent of technologies, the demands for oil as a fuel and as a energy resource is increasing globally. This is the reason the EOR methods are being sought after. The EOR methods assist in the extraction of almost 80% of the oils available in the reserves and hence, the global demand can be easily met. The Chemical methods of Foaming, as a technique for the enhanced oil recovery, are quite a recent find out. The Alkaline-surfactant-foaming methods utilize the principles of reducing the interfacial surface tension and the enhancement

of the mobility ratio by the process of foaming, as a method for the extraction of the crude oil. There are reported benefits of the process, however the alkaline components in the crude oil often results in the formation of carbonic acid, when dissolved in water. This carbonic acid threatens to corrode the steel containers that are used for the purification of the crude oil. This is the reason the elimination of the alkaline component from the methods of ASF methods is necessary. The chemically active foaming methods would serve the purpose adequately and hence, are being studied. This is the rationale behind carrying out this research project.

1.3 Research Question

The research questions for this project are:

- How does the salinity of the slug affect the dissemination of the oil banks and the production of the clean oil?
- Is MFOMAX potent enough to extricate the mobilized oil bank efficiently?
- Is ultra-low IFT required for the optimization of oil production?
- The comparison between MFOMAX and AOS1416 and the ability of MFOMAX in generation of strong foam
- The effect of the absence of alkali to the optimum salinity range

1.4 Aim of research

The aim of the research is to study the optimization of the efficiency of CAF techniques, in the setting of Baronia Oil fields, in context of the production of the clean oil

1.5 Objectives of research

The objectives of this research are:

- To study the influence of slug salinity on the propagation of oil bank and the production of clean oil
- To study the capability and the properties of MFOMAX
- To study the role of ultra-Low IFT
- To explore the impact of the absence of alkali on the processes

1.6 Study approach, Ethical Issues and Limitations of the research

Study approach

The research approach is realistic while the study approach is exploratory, since the experimentation of the processes are proposed to be carried out in this research project. The effects of the compounds used, their impacts, testing the abilities of the substances that could enhance the process of oil recovery and increase the efficiency of the EOR methods are all the topics that will be studied in detail in this project.

Ethical Issues

The preservation of the data that are received after the experiments, the processes that are being used for the analysis and the reports regarding the experiments needs to maintained safely. The technological advancements and the processes that are specifically utilized in the Baronia Oil fields also needs to be protected from revelation, during the period the experiment is carried out in the fields.

Limitations of the research

The time frame for the research to be carried out and the cost involved in the processes are the two main limitations of the project. The complexity of the processes makes it difficult to be executed by any layman and experts are needed for the experiments, which is another limitation of the proposed study.

Literature Review

The physical and the chemical factors that control the oil bank formation

The oil bank is the part of the oil reservoir where the saturation of the oil increases due to the enhanced oil recovery methods that are applied to the reservoirs (Saraji *et al.*, 2013). The formation of the oil bank is necessary since it facilitates the collection of the oil from the fields later. The more the number of oil banks in a particular field, the more is the ease with which the oil can be collected from the reservoirs. Without the formation of the oil banks, the collection of the oil becomes difficult; since the oil drilling and the recovery processes cannot be carried out through the vast expanse of the whole oil field. The Baronia Oil fields is a place where the oil banks are not very properly formed and hence, the oil bank formation is encouraged with the use of artificial methods like the water and the gas injection technologies and the usage of the surfactants in the reservoirs (Moeini *et al.*, 2014). A number of physical and chemical factors that influences the formation of the oil bank in the oil fields:

The physical factors can be enlisted as follows:

The capillary number and the viscous forces- The capillary number is the measure of the comparative outcomes of the action of viscous forces and surface tension that acts between the liquid and gas interface or between two immiscible liquids (Salager *et al.*, 2013). The capillary number is inversely proportional to the surface tension or the interfacial tension between the two different fluid phases that is when the surface tension increases, the capillary number decreases and vice- versa. The surface tension, on the other hand, increases or decreases with the rise and fall in the concentration of the surfactants used in the process of oil extraction (Lu, J *et al.*, 2013). Thus, the factors and their impacts are interrelated. The less the capillary number, the more is the driving force for the formation of the oil bank.

The natural pressure conditions of the reservoirs- The natural pressure conditions in the oil fields acts as a driving force for the extraction of the oil from the fields. The pressure conditions gather all the oil at one place and help it rise to the surface. The pressure thus, has a partially negative impact on the oil bank formation; it instead helps in the oil mobility (Bera *et al.*, 2014). Since, the natural pressure is not efficient enough for the complete extraction of the oil, thus, the oil bank formation is partially assisted, by the natural pressure conditions in the reservoirs.

The external forces applied through the water and gas injection systems for extraction- The water and the gas that are injected into the fields to facilitate the extraction of the oil from the oil fields also has an impact on the oil bank formation (Johannessen and Spildo, 2013). The water injection to the fields leads to the formation of the immiscible layers and thus the surface tension decreases. This results in the increase of the capillary numbers and thus the formation of the oil bank increases. In case of the gas injections, the surface tension increases, since the gases gets mixed with oil and forms a miscible solution, which is later extracted. The increase in the surface tension decreases the capillary number and thus, the formation of the oil bank is affected adversely.

The chemical factors can be enlisted as follows:

Surfactant concentration- The surfactants are the chemicals which reduces the surface tension. The decrease in the surface tension drives the formation of the oil banks (Talebian *et al.,* 2014). The formation of the oil bank is dependent on the accumulation of the oil at a place. The decrease in the surface tension instigates the oil molecules to accumulate at one place and thus, the oil bank formation is enhanced.

The concentration of alkalis and the deprotonation effects of the same on the oils that are being recovered also has a role to pay in the oil bank formation. The deprotonation effects of the alkalis that are formed during the oil recovery processes leads to the formation of certain compounds from the naphthenic acid as and the other components of crude oil (Raeini *et al.,* 2014). These newly formed compounds acts as surfactants themselves and thus, reduce the capillary number. This results in increasing the force that drives the accumulation of oil at a single place and thus, helps in the formation of the oil bank.

The factors that control the oil-bank displacement

The oil bank displacement is the mobility of the oil bank through the reservoirs of the oil fields. The factors affecting the oil bank displacement is essentially the same as that of the oil bank formation; only their effects will be reversed. The effect of surface tension will be reversed. The more the surface tension the more is the mobility and thus, the use of surfactants will hamper the mobility (Humphry *et al.,* 2014.). The high concentration of the surfactants would adversely affect the mobility and thus the oil bank displacement.

The role and impact of capillary number will also be reversed and the more the capillary number, the more will be the oil bank displacement (Olajire, 2014). Thus, the capillary number and the oil bank displacement are directly proportional to each other.

The natural pressure conditions acts as a catalyst for the oil mobility. The pressure conditions in the oil reservoirs helps in extraction of the oil from the fields and thus plays a positive role in the oil mobility (Hezave *et al.*, 2013).

The water injection systems are less potent in the oil mobility than the gas injection systems. The water injection systems increase the oil bank formation while the gas injection aids the oil mobility processes (Zhu, , 2015).

The alkali concentration in the reservoirs would also affect the oil-bank displacement adversely. The wettability and the adsorption of the oil by the components in the reservoirs also plays a role in the oil-bank displacement. The adsorption of the oil layers by the stones and the clay components of the walls of the reservoir provide a negative force to the oil-bank displacement and hence the rate of oil-bank displacement slows down.

Ultra-low IFT and its impact on the process of optimization of oil production

The Ultra-low Interfacial Tension is generated by the mixed-surfactant systems, during the Enhanced Oil recovery processes. The values of the ultra-low IFT denotes augment in the capillary number for a particular speed of the flow of the foam in the oil reservoirs. The IFT increases the mobility of the oil banks (Muslim *et al.*, 2013). Techniques such as the alkaline-surfactant-polymer flooding and micellar-polymer flooding are utilized for achieving Ultra low IFT. The factors that influence the Ultra-low IFT can be enlisted as follows:

Surfactants tend to decrease the Interfacial tension between the flooding fluid and the crude oil targeted for recovery and this enhances the speed of the oil recovery. In order to decrease the saturation of the oil and the formation of the oil bank, the capillary number needs to be reduced. This necessitates the reduction in the IFT conditions.

The alkali that are formed by the surfactants as a result of the enhanced recovery processes, also impacts the Interfacial Tension. The naphthenic acid present in crude oils undergoes deprotonation by the action of the alkalis and functions as surfactants themselves (Talebian *et al.*, 2014). This reduces the Interfacial Tension even further.

The rate of adsorption of the oils to the walls of the reservoir, the temperature conditions inside the reservoir and the brine salinity of the fields affects the interfacial tension

The impact of the interfacial tension on the enhancement of the oil-recovery processes is undeniable. The lower the Interfacial tension, the lower is the tendency of the formation of the oil banks and hence, the more is the mobility of the oil from the reservoirs. The adsorption rates of the materials of the reservoir decreases with the decrease in the Interfacial tension and hence, more amounts of oil is extracted from the reservoirs.

The influence of the absence of alkali on the optimum salinity range and its impact

The absence of alkali in the Enhanced Oil Recovery procedures that are followed in the CAF flooding methods decreases the optimum salinity conditions of the reservoir. The absence of the alkalis reduces the problems that are usually encountered with the operations of the process of EOR (Salager *et al.*, 2013). The absence of alkalis decreases the chances of deprotonation of the naphthenic acid contents of the crude oil and the formation of extra surfactants. This enables the collection of clean oil from the reservoirs; since the surfactants that are externally injected into the reservoir helps in the aggregation of the impurities that are present in the crude oil and formation of clusters of the same, which can then, be removed.

The absence of alkali also reduces the chances of formation of carbonic acids in the oil components and hence the recovery processes becomes easier (Moeini *et al.*, 2014). The steel instruments, that are prone to corrosion, could not be hitherto utilized for the purposed. The absence of the carbonic acid and other acidic components in the EOR processes would enable the efficient usage of the machineries and their preservation as well, for long term usage.

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