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Analysis of IFT (Interfacial Tension) and Viscosity of Various Polymer Based Fluids in Enhanced Oil Recovery

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Abstract: - The purpose of this experiment is to determine IFT and viscosity of various polymer based fluid in Enhanced Oil Recovery (EOR). Viscosity is a property of a liquid and it is defined as the resistance of a liquid to flow. Interfacial tension is the force that holds the surface of a particular phase together. Enhanced oil recovery (EOR) is the implementation of various techniques for increasing the amount of crude oil that can extracted from a well. One of the main techniques in EOR is by pushing crude oil by some fluids. Each fluid has different viscosity and IFT. A correct knowledge of IFT and viscosity of fluids using in EOR gives petroleum engineering tool of efficiently manage the production process of field. This study aimed to experimentally investigate the effect of different concentration Sodium hydroxide (NaOH), Potassium hydroxide (KOH) & Xanthangum on fluids using EOR. Four samples of fluids with different concentration of NaOH, KOH & Xanthangum which is mixed with water and carbonated water were used in this study.

Keywords: - Redwood viscometer, Tensiometer, NaOH, KOH & Xanthangum different concentration with water and carbonated water in varying temperature.

I. INTRODUCTION

The viscosity of a fluid is measure of its resistance to gradual deformation by shear stress or tensile stress or viscosity is a quantity expressing the magnitude of internal friction in a fluid as measured by the force per unit area resisting uniform flow. Interfacial tension (IFT) is somewhat similar to surface in that cohesive forces are also involved. However the main forces involved in IFT are adhesive forces (tension) between the liquid phase of one substance and either solid, liquid, and gas phase of another substance. The interaction occurs at the surfaces of the substances involved that is at their interface. Oil production is separated into three phases. Primary, secondary and tertiary which is also known as EOR. EOR can increase production from a well at 75% recovery. It is used in fields that exhibit heavy oil, poor permeability and irregular faciltiness. When a fluid is injected through injection well for EOR, the viscosity & IFT playing a major role to push the crude oil out to surface. If the viscosity is high it will push more oil to out, but we use high viscosity fluid it is risk and we need to give more power to push their fluid in through injection well. If IFT is high then, it helps to produce more oil in EOR. Fluids vary their viscosity & IFT with temperature. A fluid has no resistance to shear stress is known as ideal fluid zero viscosity is observes only at low temperature, in super fluids. Otherwise all fluid has positive viscosity and are technically said to be viscous or viscous fluid. Here preparing fluid with NaOH, KOH and Xanthangum. Adding these chemicals and polymer to 100ml of water in different concentration and finding their IFT & viscosity at 40 and 60 degree Celsius. A redwood viscometer is used to determine the viscosity of different liquid composition at two different temperatures. A Tensiometer is used to find the IFT and Surface tension of these fluids.

II. BACKGROUND OF THE EXPERIMENTATION

The experiment is carried out on a Redwood viscometer to analyze viscosity and in Tensiometer to measure the IFT of different concentration of NaOH, KOH and Xanthangum liquids which are mixed with water and carbonated water at different temperature. The Redwood viscometer consists of a vertical cylindrical oil cup with an orifice in the centre of its base. The orifice is closed by a thermometer. The cylindrical cup is surrounded by water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bath by means of an immersed electric heater in the water bath. The provision is made for stirring the water to maintain the uniform temperature in the water bath and place the thermometer to record temperature of the oil.

EOR is the implementation of various techniques for increasing the amount of crude oil that can extracted from an oil field. It is also called as tertiary recovery. There are 3 primary techniques of EOR, thermal recovery, gas injection and chemical injection. A tensiometer is an instrument used to measure the interfacial and surface tension of liquids or surfaces. Tensiometers are used in research and development laboratories to determine IFT and surface tension. There are 3 main methods of finding IFT. They are Du Nouy ring method, wihelmy plate and maximum bubble pressure method. Here we using the ring or Du Nouy method of measuring the surface and interfacial tension are commonly used and the apparatus is called Ring tensiometer. To measure interfacial tension, a platinum ring is placed in the test liquid the force necessary to withdrawn it from the liquid is determined when the ring is completely wetted by the liquid.

I. Enhanced Oil Recovery

Oil production is separated into three phases: primary, secondary and tertiary, which is also known as Enhanced Oil Recovery (EOR). Primary oil recovery is limited to hydrocarbons that naturally rise to the surface, or those that use artificial lift devices, such as pump jacks. Secondary recovery employs water and gas injection, displacing the oil and driving it to the surface. According to the US Department of Energy, utilizing these two methods of production can leave up to 75% of the oil in the well. The way to further increase oil production is through the tertiary recovery method or EOR. Although more expensive to employ on a field, EOR can increase production from a well up to 75% recovery. EOR entails changing the actual properties of the hydrocarbons, which further distinguishes this phase of recovery from the secondary recovery method. While water flooding and gas injection during the secondary recovery method are used to push the oil through the well, EOR applies steam or gas to increase the production of the reservoir.

Whether it is used after both primary and secondary recovery have been exhausted or at the initial stage of production, EOR restores formation pressure and enhances oil displacement in the reservoir. There are three main types of EOR, including chemical flooding, gas injection and thermal recovery. Increasing the cost of development alongside the hydrocarbons brought to the surface, producers do not use EOR on all wells and reservoirs. The economics of the development equation must make sense. Therefore, each field must be heavily evaluated to determine which type of EOR will work best on the reservoir. This is done through reservoir characterization, screening, scoping, and reservoir modeling and simulation.

a. Thermal Recovery

Thermal recovery introduces heat to the reservoir to reduce the viscosity of the oil. Many times, steam is applied to the reservoir, thinning the oil and enhancing its ability to flow. First applied in Venezuela in the 1960s, thermal recovery now accounts for more than 50% of applied EOR in the US.

b. Chemical Injection

Chemical injection EOR helps to free trapped oil within the reservoir. This method introduces long-chained molecules called polymers into the reservoir to increase the efficiency of water flooding or to boost the effectiveness of surfactants, which are cleansers that help lower surface tension that inhibits the flow of oil through the reservoir. Less than 1% of all EOR methods presently utilized in the US consist of chemical injections.

c. Gas Injection

Gas injection used as a tertiary method of recovery involves injecting natural gas, nitrogen or carbon dioxide into the reservoir. The gases can either expand and push gases through the reservoir, or mix with or dissolve within the oil, decreasing viscosity and increasing flow.

Ii. Application of EOR

Improving recovery with steps to full-field EOR projects

The global average recovery factor for a typical oil field is approximately 40%. This results in a large amount of identified oil left behind despite an existing production infrastructure. The need to improve the recovery factor and the accelerating of the associated production is the main driver behind the many EOR schemes in practice around the world.

Accelerating the recovery of more oil

The challenge to EOR lays in the complex interaction of injected agents with the existing reservoir fluids in an ever-changing downhole environment. Many of these challenges are well known from the development of the field. The difficulty is ensuring the proper chemical interaction and subsequent flow conformance of the EOR sweep front to recover more oil, more quickly.

Making the right parametric decisions regarding a chosen EOR technique, by evaluating dynamic economic conditions, compounds these complex challenges.

Taking measurements that solve recovery problems

To ensure successful long-term recovery, engineers and geoscientists use earth models, numerical simulators, pilot studies, and sophisticated monitoring tools to make the best decisions. A dynamic reservoir model, using the full-field model built from the initial development plan, is constantly updated with the latest monitoring data acquired from surface seismic, single well logs, and inter-well data. It is the application of this collective knowledge of accurate reservoir data coupled with detailed production history that leads to the best decisions for these complex EOR problems.

Offshore EOR Applications

Although EOR applications are predominantly employed onshore, technologies are being developed to expand the reach of EOR to offshore applications. Challenges that presently exist for offshore EOR include economics of the development; the weight, space and power limitations of retrofitting existing offshore facilities; and fewer wells that are more widely spaced contributing to displacement, sweep and lag time. Currently, the application of EOR is being considered for a number of offshore developments. With successful subsea processing and secondary recovery methods employed in offshore environments through water and gas injection, the technologies to apply EOR methods is quickly nearing

III. EQUIPMENT DISCRIPTION

A. Tensiometer

A tensiometer is an instrument used to measure the interfacial and surface tension of liquids or surfaces. Tensiometer is used in research and development laboratories to determine IFT and surface tension. Here are 3 main methods of finding IFT. They are Du Nouy ring method, wihelmy plate and maximum bubble pressure method. Here we using the ring or Du Nouy method of measuring the surface and interfacial tension is commonly used and the apparatus is called Ring tensiometer. To measure interfacial tension, a platinum ring is placed in the test liquid the force necessary to withdrawn it from the liquid is determined when the ring is completely wetted by the liquid.

Du Nouy Ring Tensiometer: - This type of tensiometer uses a platinum ring which is submersed in a liquid. As the ring is pulled out of the liquid, the force required is precisely measured in order to determine the surface tension of the liquid. This method requires that the platinum ring be nearly perfect; even a small blemish or scratch can greatly alter the accuracy of the results. A correction for buoyancy must be made. This method is considered less accurate than the plate method but is still widely used for interfacial tension measurement between two liquid.

Fig.1, Tensiometer used for testing surface tension and IFT

B. Redwood Viscometer

The redwood viscometer consists of a vertical cylindrical oil cup with an orifice in the centre of its base. The orifice is closed by a thermometer. The cylindrical cup is surrounded by water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bath by means of an immersed electric heater in the water bath. The provision is made for stirring the water to maintain the uniform temperature in the water bath and to place the thermometer record temperature of oil.

Fig.2, Viscometer used for analyze viscosity.

IV. MATERIALS USED

A. Xanthangum

Xanthangum is a polysaccharide secreted by the bacterium Xanthomonas campestris, used as a food additive and rheology modifier commonly used as a food thickening agent and a stabilizer (in cosmetic products, for example, to prevent ingredients from separating). It is composed of pentasaccharide repeat units, comprising glucose, mannose, and glucuronic acid in the molar ratio 2:2:1. It is produced by the fermentation of glucose, sucrose, or lactose. After a fermentation period the polysaccharide is precipitated from a growth medium with isopropyl alcohol, dried and grounded into a fine powder. Later it is added to a liquid medium to form the gum.

B. Sodium Hydroxide (NaOH)

Sodium hydroxide (NaOH), also known as lye and caustic soda, is an inorganic compound. It is a white solid and highly caustic metallic base and alkali of sodium which is available in pellets, flakes, granules and as prepared solutions at different concentrations. Sodium hydroxide forms an approximately 50% saturated solution with water. Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in air. Sodium hydroxide is used in many industries, mostly as a strong chemical base in the manufacture of pulp and paper, textiles, drinking water, soaps and detergents and as a drain cleaner. Worldwide production in 2004 was approximately 60 million tons, while demand was 51 million tons.

C. Potassium Hydroxide (KOH)

Potassium hydroxide is an inorganic compound with the formula KOH, and is commonly called caustic potash. Along with sodium hydroxide (NaOH), this colorless solid is a prototypical strong base. It has many industrial and niche applications, most of which exploit its corrosive nature and its reactivity toward acids. An estimated 7,00,000 to 8,00,000 tons were produced in 2005. Approximately 100 times more NaOH than KOH is produced annually. KOH is noteworthy as the precursor to most soft and liquid soaps as well as numerous potassium containing chemicals.

D. Carbonated Water (H2co3)

Carbonated water (also known as club soda, soda water) is water into which carbon dioxide gas under pressure has been dissolved. Some of these have additives such as sodium chloride, sodium bicarbonate, magnesium and other minerals. This process, known as carbonation, is a process that causes the water to become effervescent. Most carbonated water is sold in ready to drink bottles as carbonated beverages such as soft drinks.

V. Procedure

To find the viscosity

1. Clean the cylindrical oil cup and ensure the orifice tube is free from dirt.
2. Close the orifice with ball valve.
3. Place the conical flask below the opening of the Orifice.
4. Fill water in the water bath.
5. Take 100mL of water and mix it with 15 gm of NaOH and stir well with the stirrer.
6. Pour the chemical solution to orifice and heat it by heating water bath and maintain uniform temperature.
7. At particular temperature, lift the thermometer and collect the solution in conical flask and note down the time taken for collecting 100mL by using a stop watch.
8. Increase the concentration of chemicals in fluid and repeat 5, 6, 7 steps for KOH and Xanthangum.
9. Repeat the above procedure steps with carbonated water.

To find the IFT

1. Clean the container and dry well.
2. Fill the container with prepared solution at same temperature to calculated viscosity.
3. Turn the spin slowly and notice when the platinum ring getting detach from fluid.
4. Do same procedure for the entire fluid sample to find IFT.

VI. OBSERVATION TABLES

Table 1: - Viscosity (in seconds) of various polymer based fluids in water at different temperature.

Water in mL	NaOH in gm	KOH in gm	Xanthangum in gm	Water+NaOH in Seconds		Water+KOH in Seconds		Water+Xanthangum in Seconds	
				40^0c	60^0c	40^0c	60^0c	40^0c	60^0c
100	15	15	15	85	77	84	73	92	83
100	30	30	30	114	94	100	86	122	103
100	45	45	45	141	104	136	118	148	116
100	60	60	60	180	118	184	136	187	130

Table:-2 Viscosity (in seconds) of various polymer based fluids in carbonated water (H_2Co_3) at different temperature.

Carbonated water (H_2Co_3) in mL	NaOH in gm	KOH in gm	Xanthangum in gm	H_2Co_3+NaOH in Seconds		H_2Co_3+KOH in Seconds		H_2Co_3+Xanthangum in Seconds	
				40^0c	60^0c	40^0c	60^0c	40^0c	60^0c
100	15	15	15	83	72	90	75	97	78
100	30	30	30	118	93	107	89	114	96
100	45	45	45	157	128	128	113	135	129
100	60	60	60	226	209	200	174	231	201

TABLE:-3 IFT (in Dynes/cm2) of various polymer based fluids in water at different temperature.

Water in mL	NaOH in gm	KOH in gm	Xanthangum in gm	Water+NaOH in Dynes/cm^2		Water+KOH in Dynes/cm^2		Water+Xanthangum in Dynes/cm^2	
				40^0c	60^0c	40^0c	60^0c	40^0c	60^0c
100	15	15	15	34	24	37	28	45	41
100	30	30	30	39	28	38	33	48	43
100	45	45	45	40	33	40	37	51	45
100	60	60	60	47	42	54	39	54	52

TABLE:-4 IFT (in Dynes/cm^2) of various polymer based fluids in carbonated water (H_2Co_3) at different temperature.

Carbonated water (H_2Co_3) in mL	NaOH in gm	KOH in gm	Xanthangum in gm	H_2Co_3+NaOH in Dynes/cm^2		H_2Co_3+KOH in Dynes/cm^2		H_2Co_3+Xanthangum in Dynes/cm^2	
				40^0c	60^0c	40^0c	60^0c	40^0c	60^0c
100	15	15	15	32	20	34	30	42	40
100	30	30	30	36	28	39	35	46	44
100	45	45	45	39	31	45	41	50	46
100	60	60	60	43	37	52	49	54	50

VII. CONCLUSION

Accurate knowledge of viscosity and IFT of fluids used in Enhanced Oil Recovery (EOR) is very essential in petroleum engineering or for a petroleum engineer for the production of maximum crude oil or efficient use of the well. This experiment shows designing of high viscosity and IFT fluid with NaOH, KOH and Xanthangum for recovery of maximum crude oil from a well. It is observed that viscosity of NaOH/KOH/Xanthangum decreases with increase in temperature of these fluids and vice versa. This is due to temperature rise of molecule of which causes decreases in cohesive forces of molecule. The decreases in cohesive force tend to increase in intermolecular distance and it leads to decrease in the interfacial tension (IFT). High viscosity and high IFT is need to maintain for better production.

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