تم تدقيق البحث من قبل
الاستاذ:
بتاريخ:
و قد تم تصحيح كافة الاخطاء و كان البحث وفق متطلبات النشر.
توقيع الاستاذ:

QAIYARA CRUDE OIL RECOVERY IMPROVEMENT USING HOT WATER WITH SURFACTANT

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Abstract

The work is a method of an improving "Qaiyara" crude oil recovery using a mixture of hot water with surfactant. Laboratory system was designed. Using this system, four tests of hot water with surfactant under various condition were conducted. The first three tests are conducted under temperatures 50, 60, 80°C respectively with mixture of hot water + 2% wt. surfactant. The fourth test is done under 80°C and mixture of hot water +4% surf. The result obtained show the efficiency of hot water with surfactant in improving the recovery. The results show proportioned relation between temperature and surfactant concentration with oil recovery.

تحسين انتاج حقل نفط الكيارة باستخدام خليط من الماء الحار واحد مركبات الشد السطحي

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المستخلص

تضمن البحث طريقة لتحسين إنتاجية نفط حقل الكيارة الذي يعتبر من الحقول المنتجة للنفوط الثقيلة، إذ تراوحت كميات الإنتاج حسب التقارير ما بين 300-1178bbl/D في السنتين الأخيرة. استخدم في هذا البحث خليط الماء الحار مع أحد أنواع مركبات الشد السطحي المعروف باسم (الزاهي). تم إعداد منظومة مختبرية لإجراء التجارب. أجريت فيها أربعة اختبارات الثلاثة الأولى تحت درجة حرارة ٥٠، ٦٠، ٨٠ مئوية مع مركب الزاهي بتركيز ٢% وزنية، أما الاختبار الرابع فقد استخدم فيه ماء بدرجة حرارة ٨٠ مئوية مع مركب الزاهي بتركيز ٤% وكانت النتائج مشجعة من خلال وجود علاقة طردية ما بين كمية الإنتاج والظروف المطبقة.

Introduction:

Heavy oils are defined as asphaltic, dense (low API gravity, 20° to 10° at 60°F), and viscous oil (100-10000Cp) that are typically composed of relatively low proportions of volatile compounds with low molecular weight such as benzene, toluene, and xylene. They also typically contain some two ring naphthalenes and high proportions of high molecular weight compounds (Paraffins, asphaltenes, resins and other compounds with high melting points and high pour points)[1].

The initial stage in producing oil from a reservoir is called primary production. During this stage oil is forced to the surface by such natural forces as:

a) Expansion of oil, expansion of the contained gas, or both; b) displacement by migration of naturally pressurized water from a communicating zone, c) drainage downward from a high elevation in a reservoir to well penetrating lower elevations [2].

Most of a reservoir oil remains in place after the natural energy pressurizing the reservoir has been dissipated. Several techniques for injecting fluids into an oil reservoir to augment the natural forces have been widely used for many years. These techniques are generally known as secondary recovery. Some reservoir, principally those containing heavy oil that flows only with great difficulty not only provide poor primary recovery but often are not susceptible to secondary methods. Enhanced oil recovery [3] would be especially useful in some of these reservoirs. Processes that inject fluids other than natural gas ad water to augment a reservoirs ability to produce oil have been designated "improved", "tertiary", and "enhanced" oil recovery processes [EOR].

EOR processes may be divided into four categories:

a) thermal, b) miscible, c) chemical, d) other

Thermal processes, where a hot invading face, such as steam or hot water or a combustible gas, is injected, in order to increase the temperature of the oil in the reservoir and facilitate their flow to the production wells by increasing the pressure and reducing the resistance to flow. Investigators studied the effect of hot fluid on oil recovery, Closmann [4] (1983) presented results of laboratory experiments conducted on a linear system to determine the effect of various parameters on residual oil saturation after steam flooding of heavy oil/ Al-Rubaiee [5] (1986) investigated experimentally the effect of cold water, hot water and steam flooding on the recovery of "Qaiyara" crude oil.

Esam Al-Attar [6] (1989) presented an experimental investigation into the possibility of improving the recovery of different kinds of Iraqi crude oils by steam injection.

Miscible processes involve the introduction of a fluid or solvent into the reservoir that will completely mix with reservoir oil and releases the forces that cause the retention of oil in the rock matrix. This allows the solvent-oil mixture to be swept to the producing well, some of these fluids or solvents are:

- Alcohol.
- Condensed hydrocarbon gases.
- CO_2.
- Liquefied Petroleum gasses.
- Exhaust gasses.

Chemical processes involve the injection of materials which are injected as slug to modify the chemical interaction of oil with its surrounding [7, 8, 9]. Chemical processes techniques involve the use of surfactant – surfactant / polymer – alkaline flooding.

Surfactant flooding use for oil recovery is goof development in petroleum technology. The effect of surfactant is to reduce the interfacial tension between oil and driving fluid, then the resistance to flow is reduced, the success of surfactant flooding depends on many factors : Formulation, cost of surfactants, availability of chemicals, environmental impact and oil price in the market [10].

Surfactant / polymer flooding is a two – step process.

The first step is injection of a surfactant slug. Surfactant breaks the surface tension between substances. The second step is the injection of a polymer mobility buffer. The purpose of polymers is to provide mobility control for a more piston – like displacement [11].

In alkaline flooding an aqueous solution of alkaline chemical, such as hydroxide carbonate or orthosilicate of sodium, is injected in a slug from. The alkaline chemical reacts with the acid components of the crude oil and produces surfactant in situ. Interfacial tension reduction is the main mechanism. Alkaline can cause changes in Wettability, however, large concentrations are required for wettability alterations. The process is complex to design due to the various reactions that take place between the alkaline chemical and the reservoir rock and fluids [12, 13].

Theory:

One of the key oil recovery problems in oil – wet reservoirs is overcoming the surface tension forces that tend to bind the oil to the rock. In water – wet reservoirs surface tension forces act to create bubbles of oil, which can block pore passages as the bubbles resist movement in the increased surface area associated with squeezing through the passages. These surface tension forces are the primary reason why reservoirs become increasingly impermeable to oil, relative to water, as the water saturation increases [14]. If interfacial tension can be reduced between the oil and the driving fluid, then the resistance to flow is reduced.

The major factor that influence phenomena is capillary number (Nca) which is defined as :

$$N_{ca} = \frac{\upsilon^{\mu}}{\sigma}$$

Where:

υ : Darcy velocity (m/s).

μ : Displacing fluid viscosity (Pa.s).

σ : Interfacial tension (N/m).

The most effective and practiced way of increasing the capillary numbers by reducing σ, which can be done by a suitable surfactant and heat application.

Experimental Work:

1- Apparatus and materials:

1-1 Sand pack tube.

It is a steel tube of 6.5 cm ID, 90 cm length. This tube packed closely with washed and dried sand of 40-60 mesh size (size of mesh pores). The sand pack has an average porosity of 38% and average permeability of about 4 darcy. Thermocouples used to monitor the temperature along the sand pack during each run. The two ends of the sand pack were fitted with two metal screens to ensure linear flow within to simulate the reservoir condition two valves placed near its two ends to circulate the hot water around the sand pack. To minimize heat losses during tests a thick glass wool insulate the system. Produced fluid is collected in a graduated cylinder (1000 cc).

1-2 Electric heat water tank:

It is a tank of 0.16 m^3 (160L) supply the system with hot water equipped with thermostat to control temperature at desired degree, it is well insulated with glass wool and supplied with suitable in and out connections. The water supplied this heater is make – up water.

1-3 Surfactant – Supply tank:

It is a tank used to prepare the surfactant and supply the mixing tank with it at desired percent.

1-4 Crude oil Container:

Stainless steel cylindrical vessel of 1000 ml capacity which is used to displace the crude oil (Qaiyara), This container provided with piston and operated by external pressure supplied by nitrogen gas.

1-5 Water Container:

It is a graduated container of 10000 cc capacity used to saturated the sand with brine water.

1-6 Pump:

Used to inject the mixture of hot water with surfactant, from mixing tank to the sand pack.

1-7 Rhotometer:

Used to control flow rate of mixture at 25 L/hr to ensure laminar flow.

2- Alkyl – benzene Sulfonate:

This type of surfactant classified as an ionic in which the surface – active portion of the molecule bears a negative charge, $RC_6H_4SO_3^- Na^+$.

Properties:

- Completely ionized.
- Water soluble.
- Free sulfonic acid.
- Its solubility is not affected by low pH.

3- Experimental Procedure:

Brine water solution used for saturating the sand pack at very low rate, the saturation is carried out under vaccum condition, and continued for many hours after the first drop of water appeared. The tested oil is displaced from its container at very low rate until water production came to an end and reached the irreducible water saturation. Before starting a run the annulus between sand pack and the casing is heated up to the desired temperature. To begin a run the mixture of hot water and surfactant is admitted into the sand pack. The produced fluids are passed through a condensing element and then collected in a graduated cylinder.

A run is terminated when oil production has fallen to allow level. Then the fluids are left for 72 hrs to allow oil segregation in order to determine the correct volumes of the fluids produced . Four hot water tests are carried out under different conditions. (Figure 1) Show the schematic diagram of the experimental system.

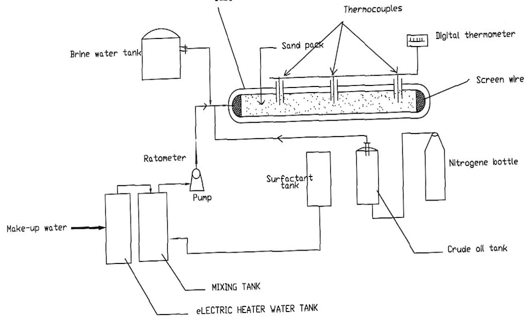

Figure 1: schematic diagram of the experimental system

Result and Discussion:

Table 1: shows a summary of the final results for all the flooding tests considered in this work with the experimental conditions.

Test No.	Temp. °C	Surfactant % wt.	Test time min.	001p% at 1.2 P.V
1	50	2%	260	55
2	60	2%	260	60.5
3	80	2%	180	71
4	80	4%	140	83

As shown in the above table, four runs by hot water with surfactant are carried out in the displacement of Qaiyara crude oil. Three runs under temperatures 50, 60, 80°C respectively with 2% wt. Surfactant liquid the forth run under 80°C hot water with 4% wt. surfactant liquid. The results obtained are plotted in (figures.2, 3, 4 and 5) These figures show the oil recovery as a function of the cumulative P.V produced. The results show that the addition of relatively small amounts of an aromatic hydrocarbon to a hot water significantly increases the recovery of Qaiyara crude oil during flooding operation.

The proper mixing of hot water and surfactant is very efficient in lowering viscosity and sweeping viscous oil.

A comparison between the runs with different temperatures and concentration of surfactant is shown in (figure 6).

An appreciable difference in oil recovery can be observed between four cases. The case of different temperature showed higher oil recovery with increasing temperature (hot water + 2% wt. surfactant). While the case of 80°C and 4% surfactant showed higher recovery than the case of 80°C with 2% wt. surfactant, this attributed to the ability of surfactant to adsorbs at some or all of the interfaces in the system and significantly changes the amount of work required to expand those interfaces, then reduce interfacial free energy rather than increases it.

(Figure 7) show the comparison of oil recovery of this work and previous work [6], in which steam injection and pressure 50 psi used for improved recovery of Qaiyara crude it shows a difference in recovery between the use of hot water + surfactant and steam flooding, the recovery at 1.2 P.V. is 83 and 67 respectively, this is due to important effects, first the lowering of viscosity because of heat the oil. This heat make oil flow or make it easier to drive with injected fluid. Second lowering interfacial tension because of using surfactant which breaks the surface tension between substances.

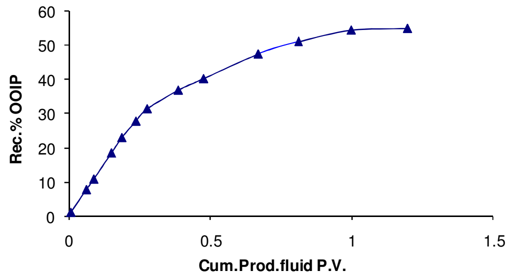

Figure 2: Rec.% vs.Cum.Prod. P.V. at 50C temp. of water with 2% wt. surfactant.

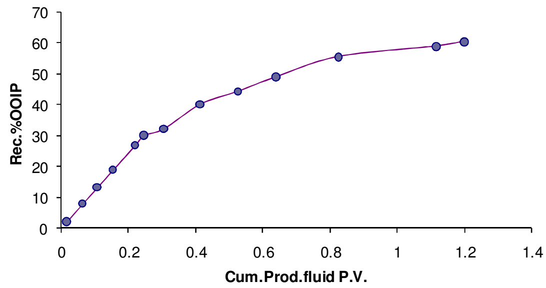

Figure 3: Rec. vs. Cum.Prod.P.V. at 60C temp. of water with 2% wt. surfactant

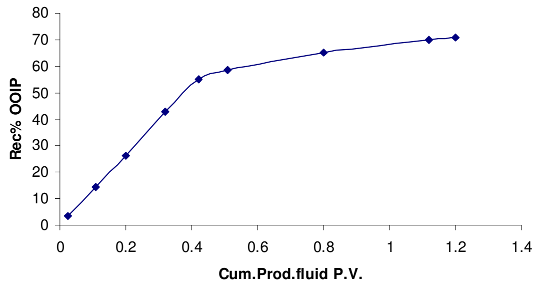

Figure 4: Rec.% vs. Cum. Prod. P.V. at 80C temp. of water with 2% wt. surfactant

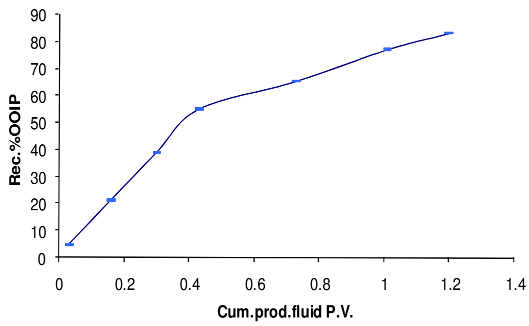

Figure 5: Rec.% vs. Cum.Prod.P.V. at 80C temp. of water with 4% wt. surfactant

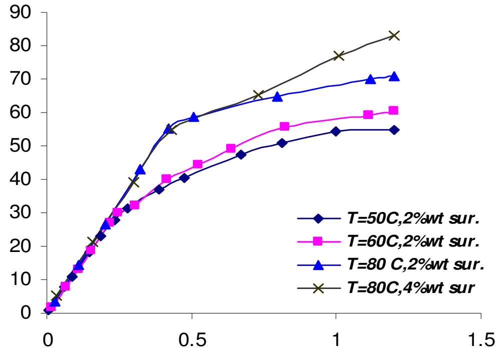

Figure 6: Oil recovery vs. Cum.Prod. P.V. for Qaiyara oil under various condition.

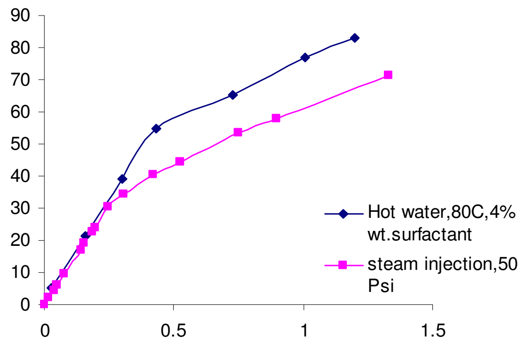

Figure 7: Comparison between Qaiyara oil recovery of this work and previous Work(6).

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