بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

Sudan University of Science and Technology

Collage of Petroleum and Mining Engineering

Petroleum Engineering Department

Project Submitted to College of Petroleum and Mining Engineering in Partial Fulfillment of the Requirements for the Degree of bachelor of science in Petroleum Engineering.

Evaluation of multifunctional chemical agent as stimulation technique to improve productivity in bamboo oil field – Case study Sudan .

تقييم فعالية العامل الكيميائي متعدد المهام كتقنية لتحسين الانتاجية – دراسة حالة حقل بامبو النفطي – السودان

Prepared by :

1- Ahmed Salah Fdl almola Ahmed.
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Supervisor :

Mr. Mohanned Khairy

November , 2020

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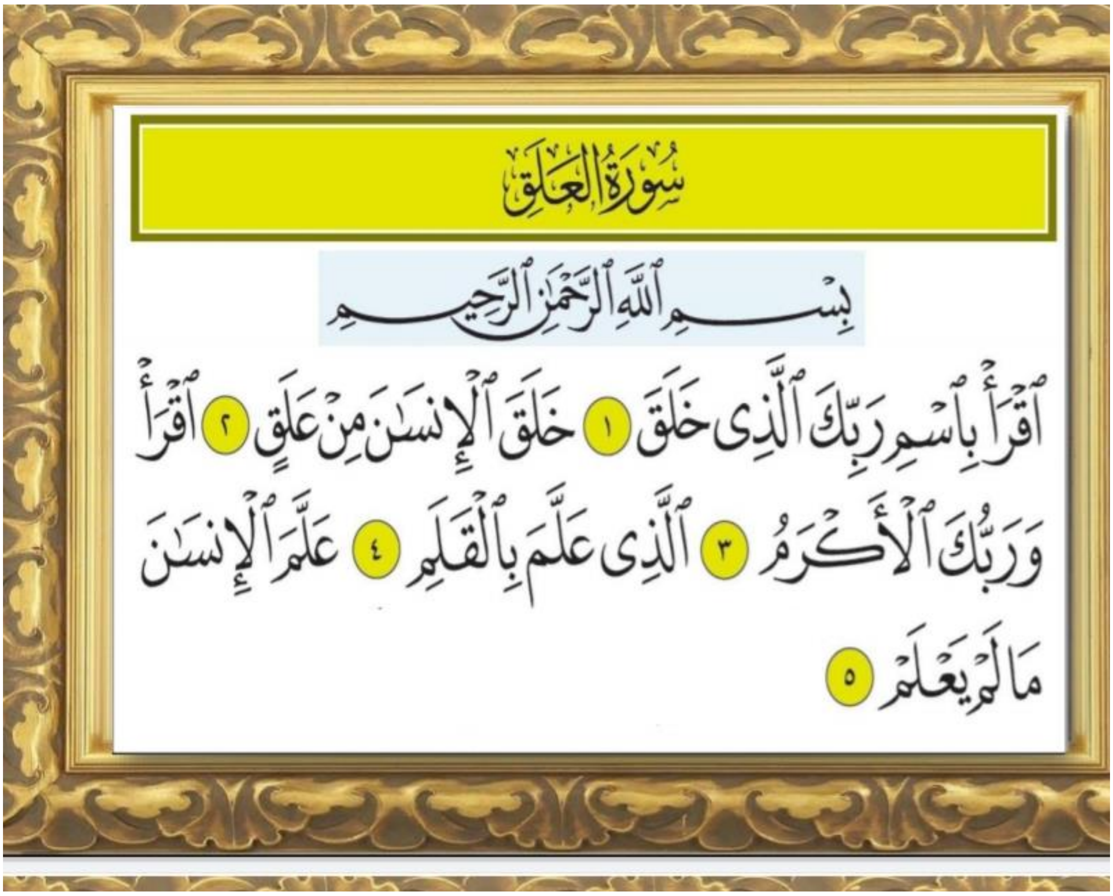
Date: / / 2020

بسم الله الرحمن الرحيم


سُورَةُ العَلَق
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مَا لَمْ يَعْلَمْ ٥

Dedication

We would like to donate this unpretentious effort to

Our Parents

; Who have endless presence and for the never ending love and encouragement

Our brothers and sisters;

Who sustained us in our life and still

Our teachers;

Who lighted candle in our ways and provided us with light of knowledge

Finally; our best friends;

Our Classmates

Researchers…

Acknowledgements

Thanks to Allah before and after...

First and foremost; the greatest thanks to our teachers for their continuous support... and for their great efforts, they were the best guide and ad monitor... Special thanks to Engineer Mohanned khairy for his assistance, providing technical support whenever we needed…

Finally; thanking to our colleagues and workers at College of Petroleum & Mining Engineering for their cooperation...

Abstract:

Bamboo field is located in block 2A Muglad Basin covers an area of 144 Square km. It consists of multi block, multi-layered under-saturated sandstone reservoir of late Cretaceous ages buried at depth ranging from 1000 m to 1700 m with crude oil viscosity ranges from 70 cp to 3000 cp.

This study discuss the massive decrease in productivity in the field due to deposition of organic materials such as asphaltene and paraffin which is not only negatively affect the oil production rate , but also entails costly and time-consuming. Problems occur when these organic solids adhere to the formation or mechanical surfaces reducing production. by operating in order to tackle the excess productivity problem effectively, it is vital to identify the source of the problem first .and therefor accurate methodology required to diagnose and evaluate increasing productivity mechanism .

pipesim program is used to evaluate the effectiveness of the multifunctional chemical MFCA agent as stimulation fluid for removing the organic material , reduce the viscosity and improve well productivity .

After running the program before and after pumping the MFCA using the given data from the bamboo oil field for four wells. two wells BBE-1 and BBW-21 have responded to the MFCA process and show good productivity(BBE-1 from 0.05032 to 0.30329)(BBW-21 from 0.1925 to 0.46615), while BBW-54 and BBW-55 productivity remained almost the same , the viscosity of crude oil decreased.

التجريد :

حقل بامبو النفطي يتواجد في حوض المجلد مربع 2A بمساحة 144 كلم مربع . يتكون من مكمن صخر رملي فوق المركز متعدد المربعات والطبقات من حقبة عصر الطباشيري مدفون على عمق يتراوح من 1000 متر الى 1700 متر بنفط ذو لزوجة بين 70 ستني بواز و3000 سنتي بواز .

هذه الدراسة تناقش النقصان الكبير في مؤشر الانتاجية في الحقل بسبب ترسب المواد العضوية مثل الاسفلتين والشمع (البرافين) . هذه المواد لها تأثير سالب على معدل انتاج النفط ,و تحمل معها مشاكل تستهلك الموارد المالية والزمن .تحصل المشاكل عندما تلتصق المواد العضوية بالطبقة والمنشئات على السطح مقللة للإنتاجية . مهم جدا ان يتم التعرف على مصادر ومسببات هذه المشاكل اولا . وعليه فانه تلزم طريقة عمل دقيقة لتفحص وتقييم الية زيادة الإنتاجية.

استخدم برنامج PIPESIM لدراسة فاعلية العامل الكيميائي متعدد المهام كمائع تحسين لإزالة المواد العضوية , وتقليل اللزوجة وزيادة الانتاجية وفق الشروط قبل وبعد حقن عامل التحسين باستخدام البيانات المتوفرة من اربعة ابار .اثنين من هذه الابار BBE-1 و BBW-21 ظهر بهن زيادة في مؤشر الانتاجية من 0.05032 الى 0.30329 و 0.1925 الى 0.46615 من بينما الابار BBW-54 و BBW-55 ظلت تقريبا ثابتة .

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LIST OF ABBREVIATIONS & SYMBOLS USED

MFCA	Multi-functional Chemical Agent .
PIPESIM	Schlumberger Pipe Simulator
STB	Stock Tank Barrel
psi	Pounds per square inch
md	Milli Darcy
scf	Standard Cubic Feet
Pwf	Bottom hole Flowing Pressure
Pr	Reservoir pressure
J	Productivity Index
SYET	Shanghai Yarun Energy & Technology Co.,Ltd

Chapter 1

1.1 Introduction

Crude oil is a complex mixture of saturates (paraffins/waxs), aromatics, naphthenes, asphaltenes and resins hydrates. Thermodynamic changes during production, storage, transportation and refining of crude oil can adversely affect the chemical equilibrium resulting in physical changes. Localized changes include those resulting from drilling, stimulation and work over procedures, These changes often induce paraffin crystallization and or asphaltene flocculation and precipitation. Problems occur when these organic solids adhere to the formation or mechanical surfaces reducing production.

1.2 About the field:

Bamboo field is located in block 2A Muglad Basin covers an area of 144 Square km. It consists of multi block, multi-layered under-saturated sandstone reservoir of late Cretaceous ages barried at depth ranging from 1000 m to 1700 m with crude oil viscosity ranges from 70 cp to 3000 cp. The total Field STOIIP and Recovery Factor (RF) are currently estimated at around 506MMSTB and 18% respectively through primary depletion. Up to date; the field had recovered more than 75% of the EUR.

The field initially produced around 20,000 STB/Day with early water breakthrough and very minimal gas production rate until today. However the production rate declined rapidly when the water production rate increased. Major factors that contributed to this problem are possibly due to the fingering and water conning. Currently the field is producing around 8000 STB/Day with water cut around 80% and keeps increasing.

1.3 Field review :

Greater Bamboo fields are located in Block 2A area of Muglad Basin which consist of four (4) oil producing structures; namely Bamboo Main, Bamboo West (-Bamboo AG), Bamboo East and Bamboo South. The main producing sands are Bentiu-1, Bentiu-2 & 3. Bamboo Main field was discovered by Chevron in 1982, Bamboo West field was discovered in December 1997 followed by Bamboo South in February 2000 and Bamboo East in September 2000. Greater Bamboo is one of biggest field of GNPOC consisting of 25% of total GNPOC STOOIP and also contained 85% of the Heavy Oil Resources in GNPOC. The 1st oil production was commenced in July 2001 and a peak production of ~20Kpopd was achieved in July 2002. As in Jan 2016, the total cumulative oil production of Bamboo fields is 64MMSTB, recovery of 12.6% of the total STOIIP of 506.4MMSTB (GNPOC, 2015).

The reservoir rock and crude oil properties for Greater Bamboo fields summarize as per table1.

Table 1—The reservoir rock and crude oil properties for Greater Bamboo fields (GNPOC,2015)

Parameters	Greater Bamboo
Reservoir Formation	bentiu & Aradeiba
Top Depth, mKB	1300
Initial Res, Pressure, psia	2300
Current Res, Pressure , psia	1600
Temperature , C	60-70
Porosity Fraction	0.23
Permeability, mD	300-10000
Oil Gravity, API deg	15-25
Viscosity, cp	70-3000

1.4 Problem statement

Bamboo oilfield current performance shows that; the fields producing around 8 Kbod. All producers are producing with PCP, ESP or Beam Pump Unit (BPU). The fields contain heavy crude oils with more than 3000 cp that poses great challenges to production with conventional completion and production methods which most likely the major concern for very low oil recovery. Heavy crude and aspheltene appeared as one of the most common challenges in Bamboo oilfield , they causes reduction in the productivity by chocking the near wellbore zone.

Due to unfavorable results from previous production data there is a need to seek other options that offers better cost and high efficiency . this can be achieved by using MFCA as a production stimulation method.

1.5 The main effects of MFCA can be summarized as follow:

1-Viscosity reduction.

2. The energy support for oil displacement in the form of chemical flooding;
3. Lower oil/water interfacial tension to reduce the capillary force, viscous force of fluid. improve the efficiency of wash oil and thus make the oil droplets flow through smaller throat under the small pressure difference;
4. Alter rock wettability from oil-wet to water-wet and improve the oil phase permeability;
5. dissolve the deposit heavy organic substance near wellbore zone, therefore restore its reservoir permeability, so as to clean the flow channel and reduce the flow resistance. in addition, the chemicals sticking in the reservoir pore and wellbore has the function of preventing the asphalt remaining in the reservoir pore and wellbore. (clarification of MFCA SYET report 2016)

1.6 objectives:

To analyze the performance of MFCA blends as stimulation solvents for organic deposits in bamboo oil field in order to investigate the key parameters that determine the degree of success/failure of the MFCA application to solve the damage caused by the organic deposits and increase the productivity.

Determine the shift in the production conditions.

Determine the changes in the productivity index.

Chapter 2

2.1 General background :

2.1.1 Paraffin

The paraffin or n-alkane components account for a significant portion of a majority of crude oils that are > 20º API. Paraffin has a straight chain linear structure composed entirely of carbon and hydrogen. The melting point varies from -295ºF for methane gas (CH_4) to >240ºF for Hectane ($C_{100}H_{202}$). The longest naturally occurring n-alkane in crude oil actually is currently unknown. The largest detected by this author is a $C_{103}H_{208}$. The paraffin > $C_{20}H_{42}$ are the components that cause deposition or congealing oil in crude oil systems. Paraffin can deposit from the fractures in the formation rock to the pipelines that deliver oil to the refineries. The deposits can vary in consistency from rock hard for the highest chain length paraffin to very soft, mayonnaise like congealing oil deposits.

Solvency has been one of the primary methods of controlling these deposits during the last century. Depending upon the type of deposit being dissolved, its location in the system, the temperature and type of application, complete success has been elusive. What worked in one field failed miserably in another field? Success downhole turned to failure on the surface. Success on land turned to failure in systems producing under water. P4 Red (carbon disulfide) was great until the rods stuck tight

2.1.2 Type of Paraffin:

By chemical definition paraffin are saturated hydrocarbons with straight or branched chains structures, but without any ring structure. This definition points to the alkanes as the true paraffin. At one time the alkanes were called the paraffin series of chemicals, but this terminology has been lost; so we have no link between the words alkanes and paraffin. The paraffin or alkanes that give us problems in the oilfield are those alkanes of $C_{20}H_{42}$ chain length and higher. The n-alkanes (straight chain) up to chain lengths of $C_{36}H_{74}$ give the majority of pour point problems. Above this carbon number they are joined by the linear and branched parafffins that become insoluble in the oil at high temperature. The alkanes above $C_{40}H_{82}$ are primarily responsible for deposition problems in the oilfield. The longest chain length alkane observed by this author from an oilfield deposit was $C_{103}H_{208}$ from a tank bottom sample. Paraffin deposits can vary in chain length from $C_{20}H_{42}$ to $C_{103}H_{208}$ in a system, and therefore have widely varying solubility characteristics. A shorter chain alkane on the surface may dissolve easily at a lower temperature while a longer chain alkane will not dissolve at all in the same solvent in the tubing.

2.1.3 Asphaltene

asphaltenes is the insoluble fraction of oil in n-pentane or n-heptane, but soluble in benzene, ethylbenzene, toluene and xylene (BETX). Asphaltenes are also defined as poly-aromatic condensed rings with short aliphatic chains and polar hetro-atoms (N, O, and S) in functional groups such as ketones, thiophenes, pyridines, and porphyrins

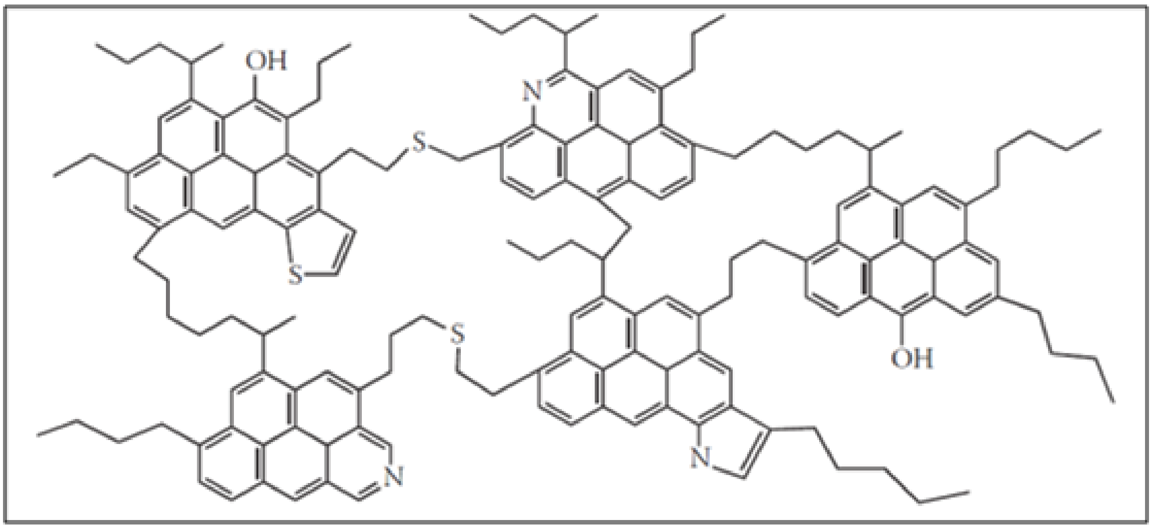


Figure (1): asphaltene formula

2.1.4 Asphaltene deposition

Asphaltene deposition is the process whereby there is attachment of asphaltene aggregates onto a surface. Depending on the interaction between the surface and asphaltenes they may adsorb on the surface (Alian et al., 2011). Asphaltene deposition studies are mainly performed using microfluidics (more specifically capillary flow), Taylor-Couette (TC) cells or core flooding experiments through a porous media. Microfluidic studies provide researchers the chance to study phenomena such as colloidal dynamics at very low Reynolds numbers, where the small dimension of the capillary or the microfluidic device offers the suitable length scale (Saha and Mitra, 2012). Furthermore, the Taylor Couette device has the advantage of studying deposition at reservoir temperature and pressure conditions. Finally, core flood experiments use surface chemical techniques such as scanning electron microscope (SEM) with energy dispersive X-ray spectroscopy (SEM-EDS) and X-ray computed microtomography to study the crude oil volumes at the pore scale in order to quantify residual oil and wettability alteration (Seifried,2016).

2.2 Formation damage and field experience :

The precipitation of asphaltenes during all phases of crude oil recovery can lead to a decrease in production efficiency. Leontaritis et al. (1994) stated that generally four forms of formation damage induced by asphaltene deposition can be defined: (1) The physical blockage or permeability reduction, (2) wettability alteration, (3) a crude oil viscosity decrease, or (4) the formation of a water-in oil emulsion. Mechanism (1), however, seems to be the dominant one causing formation damage. The first step of asphaltene deposition is the adsorption of the asphaltene molecules on the surface of the rock, followed by hydrodynamic retention and/or trapping of the particles at the pore throat, eventually leading to a reduction of the effective hydrocarbon mobility (Nghiem et al., 1998; Al-Maamari and Buckley, 2003). Zekri et al. (2007) investigated how different flow rates in dynamic flow experiments affected formation damage due to asphaltene deposition. They stated that a decrease in the flow rate may reduce the formation damage for crude oils with a relatively high content of asphaltenes. According to Kokal and Sayegh (1995), some of the factors which influence adsorption of asphaltenes on the mineral surface are: (1) The morphology and chemistry of the mineral surface, (2) the amount of asphaltenes and resins present in the crude oil, (3) the composition and pH of the brines in the reservoir rock, and (4) pressure and temperature in the reservoir rock. Leontaritis and Mansoori (1988) reviewed several experiences of the oil industry dealing with asphaltene issues during production in the Mata-Acema and Boscan fields, Venezuela. The reservoir in the MataAcema field is made out of sandstone where the producing fluid contains mainly C71 fractions with an asphaltene content of 0.4%9.8%. The asphaltene issues reported from this field were severe, whereas no asphaltene problems were reported from the Boscan field. The Boscan field is a sandstone and produces mainly heavy oils with an asphaltene content of 17.2%. Alian et al. (2011) and Behbahani et al. (2012) attributed the differences to the lower solubility of asphaltenes in lighter crude oils in the Mata-Acema field. The asphaltene content from the stock tank oil produced from the Hassi Messaoud field sandstone reservoir (Algeria) was measured to be 0.062%. Despite the very low asphaltene content, deposition problems were reported from the start of the production onwards. Wells lost up to 25% of the wellhead pressure in only 2 weeks, causing significant loss in production. \ Furthermore, a solvent treatment and circulation of oil were used in the Ventura Avenue field (California) to avoid or reduce deposition, however, this did not lead to a great improvement in oil recovery.

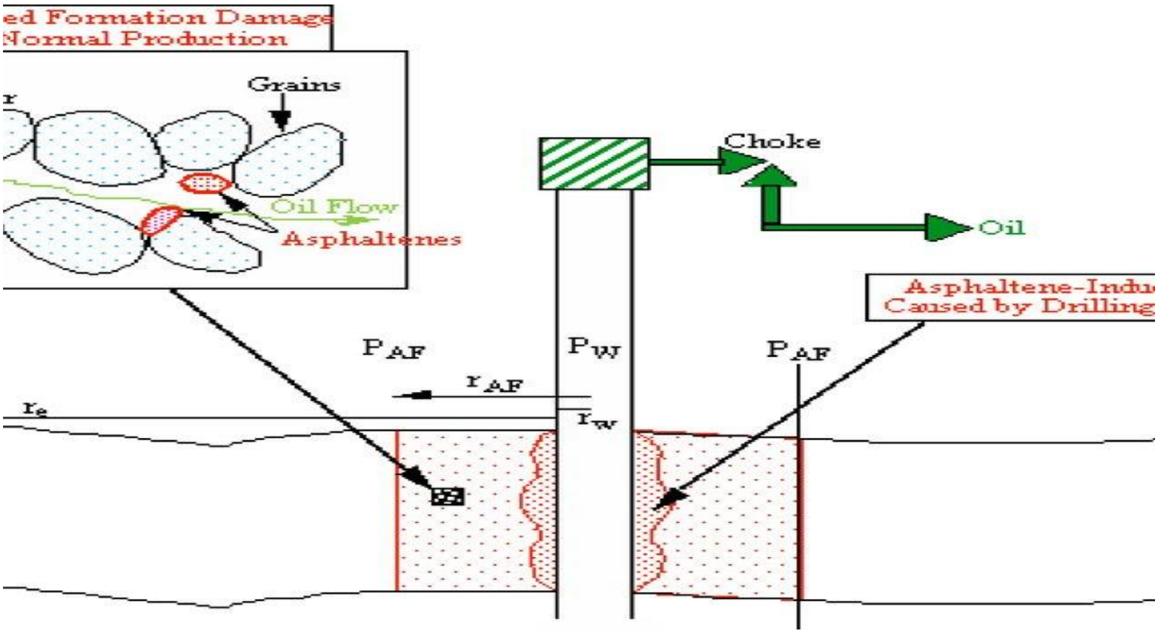


Figure (2) : formation damage with asphaltene

2.3 Solvents:

Solvents cover a broad range of materials that dissolve and disperse deposits and damage problems in the well. The most common solvent is fresh or brine water, used to remove salt, or as a base fluid to carry surfactants, alcohols, mutual solvents and other products. Alcohols are a special class of sol- vents since they have solubility in both oil and water. Hydrocarbon solvents are also used with regular- ity.35-38 These materials include crude oil and condensate, plus refined oils such as diesel, kerosene, xylene and toluene. The reasons for the use of solvents are that acid has little or no effect on may damaging deposits. Selecting a solvent usually requires some testing with the damage deposit. A few selected organic solvents are shown in Figure

Table 2 some organic solvents

Fluid	Used to Remove	Density		Flash Point	
		(lb/gal)	(kg/l)	(F)	(C)
Methyl alcohol	water blocks	6.6	0.79	52	11
Diesel	paraffin (poor)	6.7	0.80	100	38
Kerosene	paraffin	6.7	0.80	100-165	38-74
Toluene	most organics	7.2	0.87	40	4
Xylene (meta)	most organics	7.1	0.86	84	29
Xylene (para)	most organics	7.1	0.86	103	39
Xylene (ortho)	most organics	7.1	0.86	90	32
Xylene bottoms	solvent quality varies	varies		varies	
Naphtha	solvent quality varies	varies		100	38
Oil	solvent quality varies	varies		varies	
Gasoline	paraffin	about 7		-45	-44

In this project we will work with MFCA solvent

2.4 Multifunctional Chemical agents :

2.4.1 Zwitterionic surfactant (ZS):

Surfactants that are composed of two hydrophilic and two hydrophobic groups have been the subject of significant research interest since the early 1990s. These surfactants are called “Gemini” because their chemical structures can be perceived as two classic surfactant molecules chemically connected at or near the head groups. Their chemical arrangement provides a rich array of aggregate morphologies and solution properties that are dependent upon the nature and size of the linking group and/or head groups. These types of surfactants with unsymmetrical geometry have interesting characteristics in terms of self-assembly into aggregates and packing at interfaces. (Clarification of MFCA SYET report 2016)

Zwitterionic surfactants (ZSs) are considered among the surfactant molecules that can be applied in EOR with molecular structures made up by two hydrocarbon chains, a bridge, and two polar groups of zwitterionic type that can be a cation and an anion in different atoms of the same molecule. ZSs are electrically neutral, and they can behave as bases or acids (acceptor or donor) according to the properties of the medium where they are found. Therefore, zwitterionic surfactants can play a role as smart wettability modifiers that react efficiently according to the characteristics and properties of the specific medium. (Clarification of MFCA SYET report 2016)

Figure (2) displays the general chemical structure of zwitterionic surfactants (ZSs), which corresponds to a recently developed alkyl betaine zwitterionic gemini surfactant with polyethylene spacers .This molecule was designed as a wettability modifier of rock surfaces such as limestone, dolomite, sand, quartz or heterogeneous lithology in the presence of brines with high content of divalent ions (i.e., calcium, magnesium, barium, and strontium), high temperature, and high pressure for EOR applications.

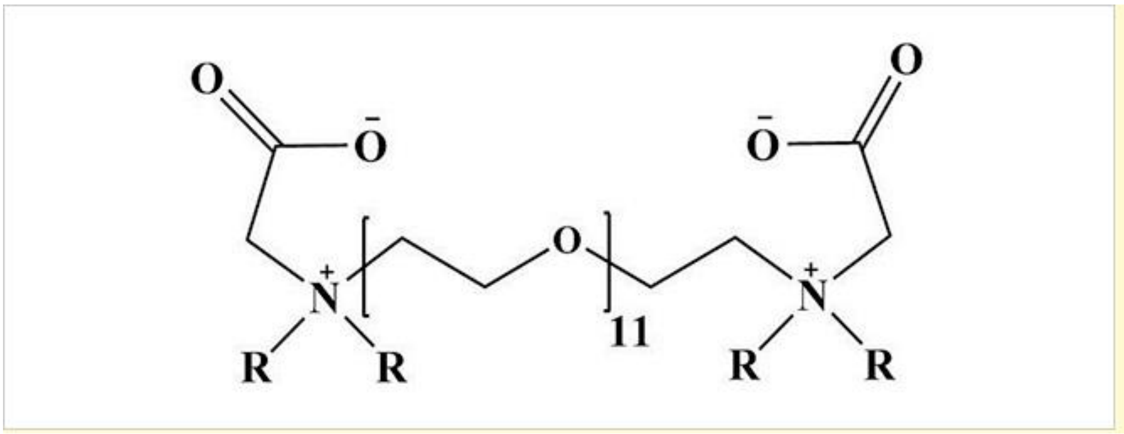


Figure 3 General chemical structure of the geminal zwitterionic surfactant.

2.4.2 Supramolecular complex:

Supramolecular chemistry is based on the phenomenon of molecular recognition through weak forces between molecules, which promotes self-assembly .This is a promising technology that has impacted the design of new materials with interesting applications in the chemical industry including the petroleum industry. (Clarification of MFCA SYET report 2016)

Supramolecular technology has been used for EOR applications. For instance, supramolecular assemblies, such as micellar structures, have been developed for applications in wettability alteration where it is beneficial to modify the rock formation wettability from oil-wet to preferentially water-wet to enhance oil recovery .It has also been reported that supramolecular agents can interact with crude oil fractions within the reservoir to reduce their viscosity promoting additional recovery of residual oil. (Clarification of MFCA SYET report 2016)

The supramolecular complex, AMESUS, is a surfactant developed from the interactions among cocamidopropyl hydroxysultaine (CAHS), sodium dodecyl alpha-olefin sulfonate, and sodium dodecyl hydroxyl sulfonate. AMESUS offers multifunctional features including foaming, corrosion-inhibition, and wettability-alteration properties. AMESUS can be used in high salinity brines at reservoir conditions without alteration of its molecular structure .Figure (3) shows the characteristic chemical structure of a supramolecular structure.

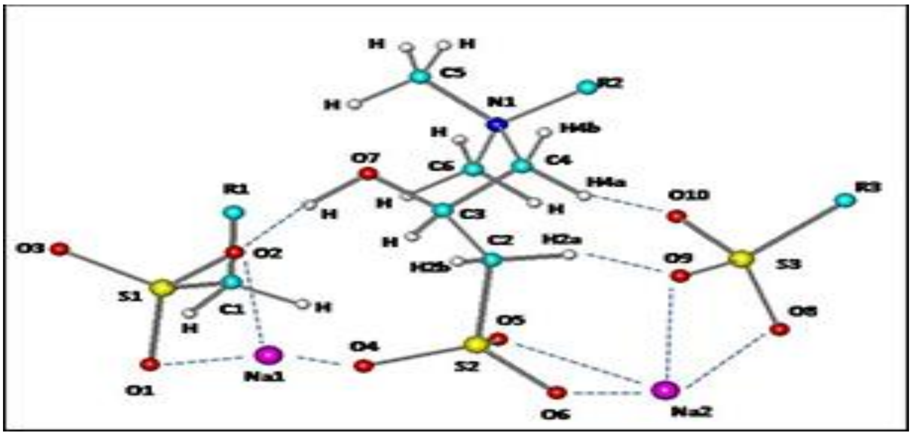


Figure 4 Characteristic chemical structure of the supramolecular complex, wherein R1, R2, and R3 are alkyl, alkenyl linear, or branched chains, whose length ranges from 1 to 30 carbon atoms

2.5 Evaluation of the multifunctional properties:

2.5.1 Interfacial tension (IFT) and contact angle:

The dominant oil recovery mechanisms during surfactant flooding are interfacial tension (IFT) reduction and wettability alteration. The mobilization of residual oil requires the reduction in the interfacial tension at the oil-brine interfaces to ultralow values to overcome the capillary forces responsible for trapping residual oil at the pore scale .Therefore, IFT reduction mechanism depends on the surfactant effectiveness in reducing the oil-water IFT by four to six orders of magnitude. Figure 3 shows the interfacial tension as a function of surfactant concentration and surfactant type (AMESUS and a ZS) obtained from a light crude oil (31° API)—high-salinity brine (2.6 wt.% NaCl) system. (Clarification of MFCA SYET report 2016)

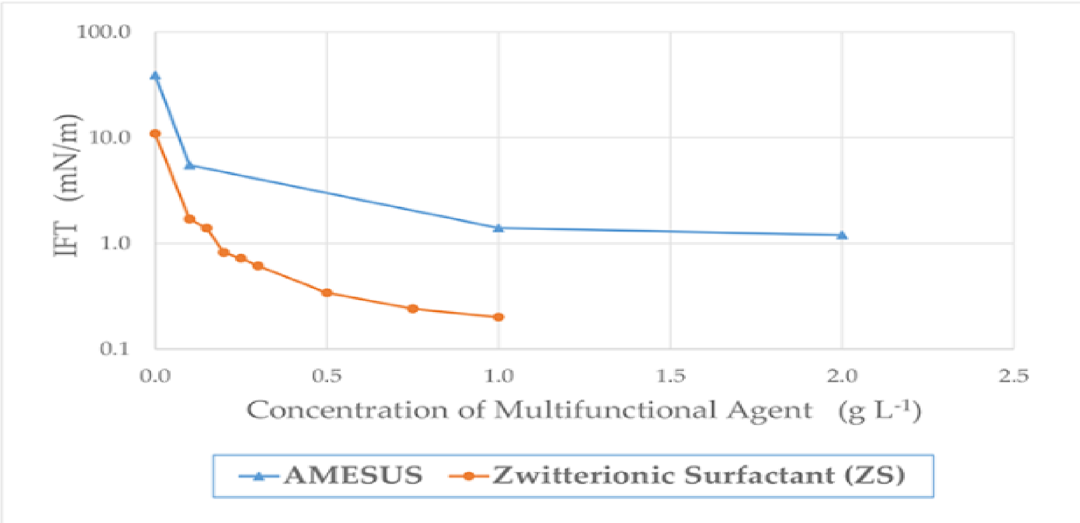


Figure 5. Interfacial tension (mN/m) as a function of surfactant concentration and surfactant type. (SYET 2016)

As expected, multifunctional agents (surfactants) decrease the interfacial tension as the concentration of surfactant increases until the critical micelle concentration is reached. According to the data presented in Figure 3, “ultra-low” IFT values were not obtained for this system with these surfactants. However, it is important to realize that oil recovery is not only influenced by IFT reduction, there are other several factors affecting the mobilization of oil at pore scale such as rock wettability (contact angle), capillary and viscous forces, and fluid properties, among others .Wettability determines the adhering tendency of a fluid toward a solid surface in the presence of other immiscible fluids, and it is a function of the interfacial chemistry of the phases present in the system.

Contact angle is the point at which the oil or water interface meet at the solid (i.e., rock) surface; therefore, it indicates the affinity of the solid surface for any of the fluids present in the system. Contact angle determination is commonly used to establish wettability changes of solid surfaces .In this regard, reliable wettability alteration measurement tools are necessary for the accurate evaluation and monitoring of wettability alteration treatments. (Clarification of MFCA SYET report 2016)

Figure (5) shows the effect of multifunctional agents (i.e., surfactant) addition on the contact angle for each system as a function of time. The solid surfaces used were carbonate minerals (dolomite), and the concentration of multifunctional agents was 0.1 g/L in high salinity brine concentrations (3.2 wt.% NaCl). As observed in Figure (5), both multifunctional agents changed the contact angle between oil and the solid surface. In the AMESUS system, the contact angle was changed from 0 to 51°, while for the ZS system the contact angle changed from 0 to 30°. These results demonstrate the effectiveness of these additives as wettability modifiers. Therefore, these results show that despite the slow decrease in interfacial tension, these multifunctional agents are efficient in altering the rock wettability. (Clarification of MFCA SYET report 2016)

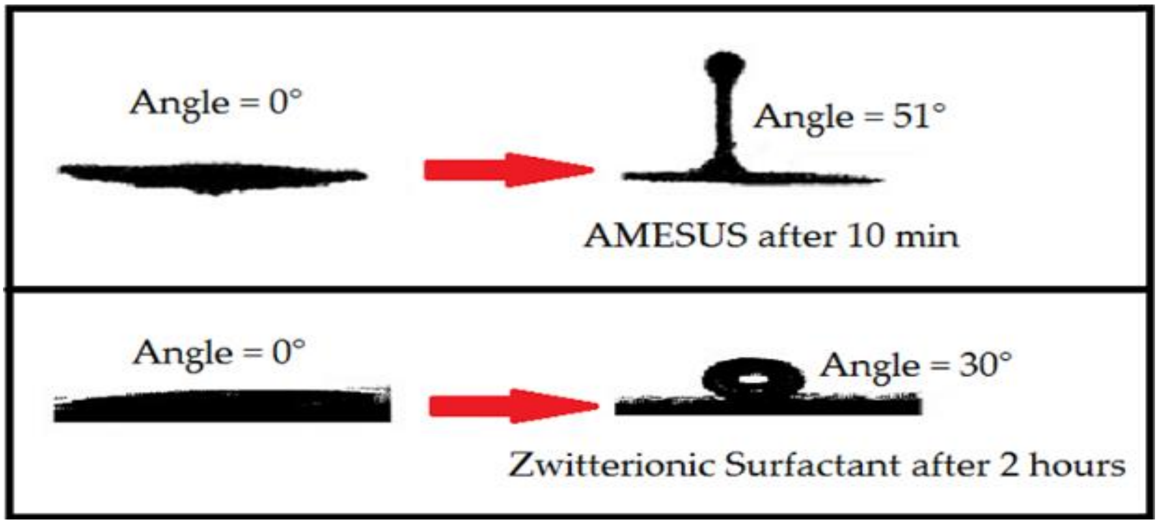


Figure 6 .Effect of multifunctional agents on contact angle between oil and the solid surface.

2.5.2 Asphaltenes aggregation inhibition and dispersion activity:

Asphaltenes can be defined according to their solubility as the fraction of oil that is insoluble in low-molecular-weight alkanes, specifically n-pentane and n-heptane, but completely soluble in aromatic hydrocarbons, such as benzene and toluene. Asphaltenes fraction is formed of associated systems of polynuclear aromatics bearing alkyl side chains and organic molecules containing oxygen, nitrogen, sulfur, vanadium, and nickel porphyrins .Asphaltenes are known to aggregate due to the propensity of their fused aromatic ring systems to stack via π-bonding . (SYET 2016)

Oil production operations can induce asphaltenes precipitation because of pressure and temperature decrease and oil-phase compositional changes. The disruption of the initial reservoir conditions could induce undesirable phase separation that negatively impacts every stage of the oil production process. As mentioned earlier, deposition of asphaltenes aggregates onto the rock surface can modify the wettability of the reservoir from water-wet to oil-wet, affecting significantly the oil displacement efficiency during the oil recovery processes. Thus, surfactants agents designed for chemical enhanced oil recovery must effectively interact with the heavy fractions of the crude oil such as asphaltenes and resins. Surfactants must inhibit their aggregation and/or disperse their aggregates to prevent their deposition or accumulation onto the rock surface, which would alter the wettability and the effective permeability of the formation rock affecting oil sweep efficiency. (Clarification of MFCA SYET report 2016)

Multifunctional agents used as asphaltenes aggregation inhibitors have been evaluated through ultraviolet-visible (UV-vis) spectroscopy by determining the concentration of asphaltenes remaining in solution after induced precipitation with n-heptane .This study was carried out taking advantage of the insolubility of the asphaltenes fraction in low-molecular-weight alkanes such as n-heptane. However, under these conditions, the addition of the chemical agents promotes a colloidal stability to the asphaltenes particles in the liquid phase by preventing their aggregation through steric hindering or by modifying the electrostatic forces involved in the system. (Clarification of MFCA SYET report 2016)

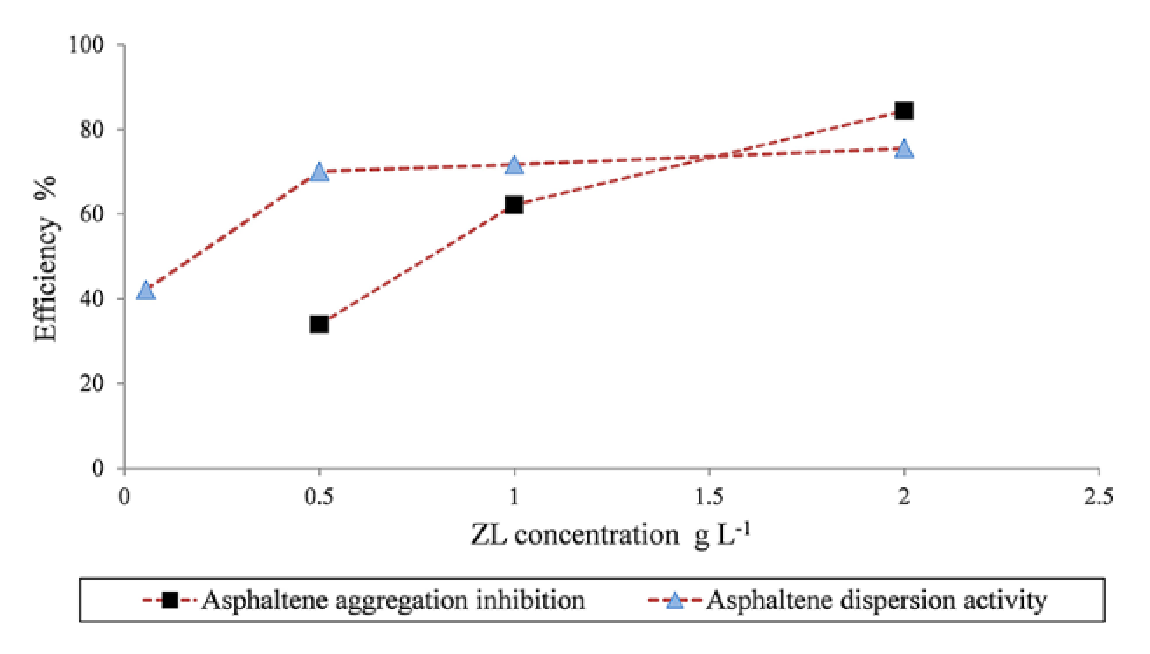


Figure 7. Performance of zwitterionic surfactant on asphaltenes aggregation inhibition and dispersion activity.

shows the effect of the zwitterionic surfactant (ZS) on asphaltenes aggregation inhibition and dispersion activity. The evaluations of the inhibition properties were carried out using solutions (1000 μL) of 5.0 g/L of asphaltenes in toluene mixed with n-heptane solutions (9000 μL) at different concentrations (0.5, 1, and 2 g/L) of ZS according to experimental techniques described elsewhere .The dispersion activity experiment was performed using a sample of sediment extracted from a light crude oil (35° API) by centrifugation and with a composition of 59.99 wt.% saturates, 20.82 wt.% aromatics, 17.47 wt.% resins, and 1.45 wt.% asphaltenes .Figure 5 shows that the efficiency of asphaltenes aggregation inhibition increases as the concentration of ZS increases, while the dispersion activity efficiency increases initially as the concentration of ZS increases but it levels off at a concentration of ZS of 0.5 g/L. (Clarification of MFCA SYET report 2016)

2.6 Literature review:

every production system struggle from decreasing in productivity with time and formation damage. Organic deposits are a common source of oil field formation damage . it has adverse effects on well performance and restrict accessibility to the wellbore and reservoir . organic deposition occurs when there are changes in well pressure ,temperature or composition during normal production operations. Many studies and laboratory tests conducted to clean out the deposition of that material like paraffin asphate wax and other heavy substance . there a large number of studies conduct to fine solution of this problem and improve productivity start by simple way and then be more extensive . Traditional methods of removing asphaltene/paraffin deposit involve heat, mechanical removal dispersant and solvents. The most common means of transmitting heat is hot oiling , this process can cause significant formation damage specially when there are asphaltene present Barker **(1989)** . in **(1989)** Saleh and Akber include mechanical removal techniques scraber , cutter, and coiled tubing these techniques have limitations because they not be able to remove formation damage outside of the perforation. In **1990** Garner, Bilden, kovacevich and Bence use a combination of coiled tubing and solvents, this tool present ability to remove most challenging of asphaltalene deposits. Water soluble dispersant have been used to remove paraffin for many years Brogden and Dill **(1969)** this dispersants system do not dissolve paraffin or asphaltene rather they disperse the particles so that they can be circulated from the wellbore .the solvents most frequently used for asphaltene cleanup are toluene and xylene and have been used to simulate low gravity oil reservoirs since the late 1960s Jeffries_Harris and Coppel **(1969)** .many companies would like to replace these chemical because of their environmental impact .refined diesel blend and deasphltened oil were also evaluated for their asphltene-solvating power Deboer, leelooyer, Eigner and Van pergan **(1995**) Jam ALuddin,Nazarko,Sills and Fuhr **(1996)**.in **(2003 Curtis)** introduced terpene-based solvents to improve health ,save ,and environmental characteristics fall short of benchmark asphaltene solvency power of toluene or xylene

Diesel is commonly used to prepare emulsified acid by being diffusion barrier between acid and rock crowe and miller (**1974)** .this give the acid ability to penetrate deeper in formation therefor the productivity improved .in **(1994),** conway et al .examined the reaction of emulsified with carbonate the result show that the reaction of emulsified acid with carbonate rock is slower that of regular acid In **(1991) -** trbovich and king conduct the study - by using a mechanical means heat, dispersant and solvent for removal and dissolution of asphaltene . Abdul Fatah and Nasr-El-Din **(2010)** reported 4 cases that use acid emulsified in xylene and effectively remove asphaltene deposition and enhance wells productivity**.** Ibrahim and Ali **(2005)** presented two pack chemical systems to remove organic deposits in and around wellbore and production tubing and enhance production rate. Boswood and krech **(2011)** presented case studies and laboratory tests for fully miscible acidizing solvent that show superiority and more economical compare with xylene .lightford et al **(2008)** presented a laboratory development and field application of a water/aromatic-solvent emulsion system which was successfully used to clean/dissolve asphaltene . A several research groups Bazin and Abdul Ahad **1999,** LINN and Naser-EL-DIN **2001 ,**Siddiqui **(2006**) indicate that acid propagated through the core plug in almost straight line ,these acid enhance core permeability by factor depending on injection rate.

Chapter 3

Methodology:

Stimulation job has been done in Sudanese bamboo oil field to four wells (BBE-01, BBW21, BBW-54. BBW-55) by using multi-function chemical agent (MFCA) to remove skin effect and improve wells productivity .

The processes conduct and the require data put in pipesim program and then run the program by using nodal analysis the result will be IPR curve and this process done for the well before and after MFCA this IPR curve results will be compare for that well to note the probable shift in operation point.

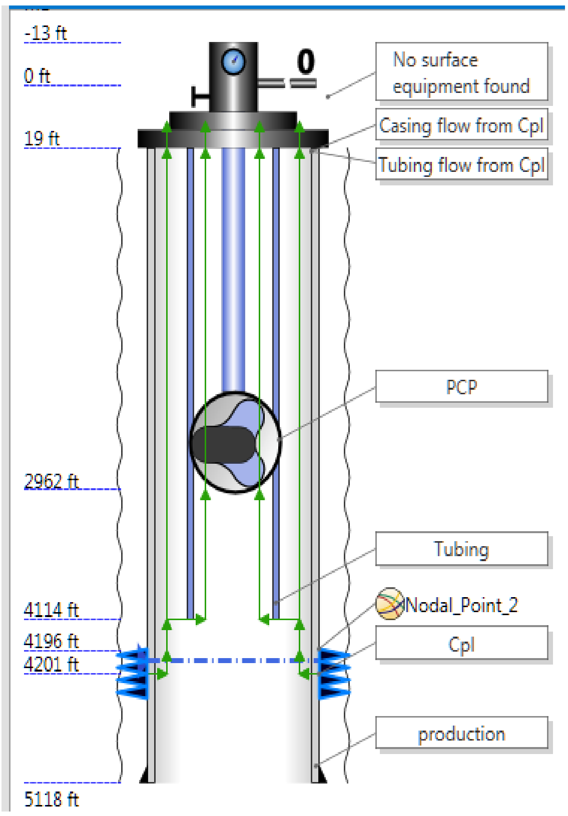


Figure 8 :well BBW-21 PIPESIM well model.

The viscosity curve will be also build for well fluid at different temperature before and after MFCA added to make a compare between them .

All this processes must be repeat to the all wells .

3.1 About the pipesim

PIPESIM is production system analysis software that provides steady-state, multiphase flow simulation for oil and gas production systems. The individual PIPESIM modules for a wide range of analyses, including well modeling, nodal analysis, field planning, artificial lift optimization, pipeline design and equipment sizing. A major feature of PIPESIM software is the system integration and openness that allows you to develop a Total Production System Model. You gain a general understanding of how PIPESIM software is used to design and optimize total production systems from the reservoir to the final processing delivery point.

3.2 NODAL analysis

Nodal analysis is used to evaluate the performance of production or injection wells. It involves specifying a nodal point, usually at the bottom-hole or wellhead, and dividing the producing system into two parts - the inflow and the outflow. This is represented graphically below.

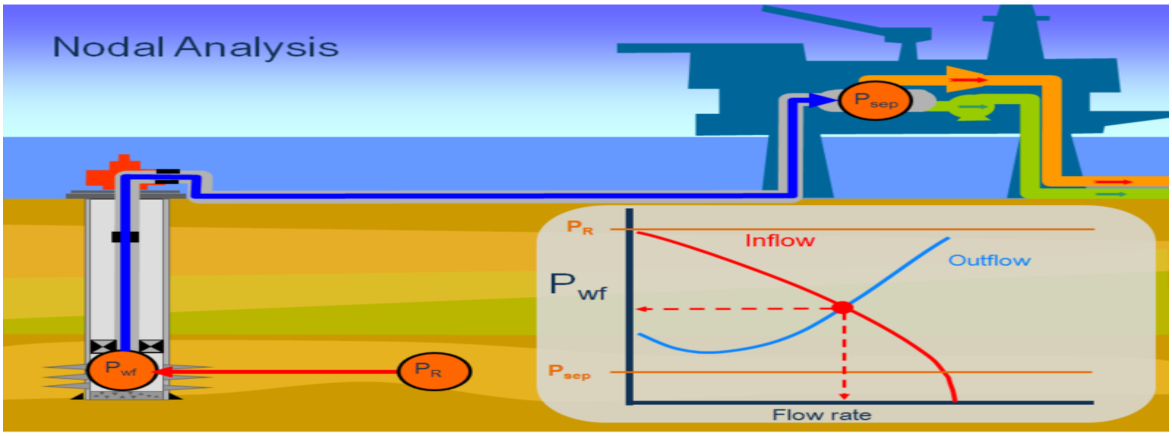


Figure 9 : nodal analysis.

TABLE 3 Sample of data required to create nodal analysis:

parameter	Para field
Reservoir pressure	1208 psi
API gravity	22
Reservoir Temperature	65 °c
viscosity	109 Cp
Water cut	30%
Production rate	150 bbl/day
Pump type	PCP

The above data table used in pipesim program to build inflow performance curve for all individual wells

3.3 Data analysis

1-the result were tabled in excel sheets .

2-graphs were drawn .

3-production data processed by pipesim software.

3.4 Calculation

below calculations are required in order to obtain the IPR curves for each well:

1- Reservoir pressure:

$$Pr = 0.433 * (h - SFL) * 3.28 * \rho \quad (1)$$

Pr is reservoir pressure psi

h is production interval meter

SFL is static fluid level

ρ is fluid density lb/cuft

2- Productivity index :

$$J = \frac{Q}{Pr - Pwf} \qquad (2)$$

J IS productivity index bbl/day psi

Q IS production rate bbl/day

Pwf is bottom hole pressure psi

Chapter 4

Results and Calculations:

4.1 Nodal analysis Results:

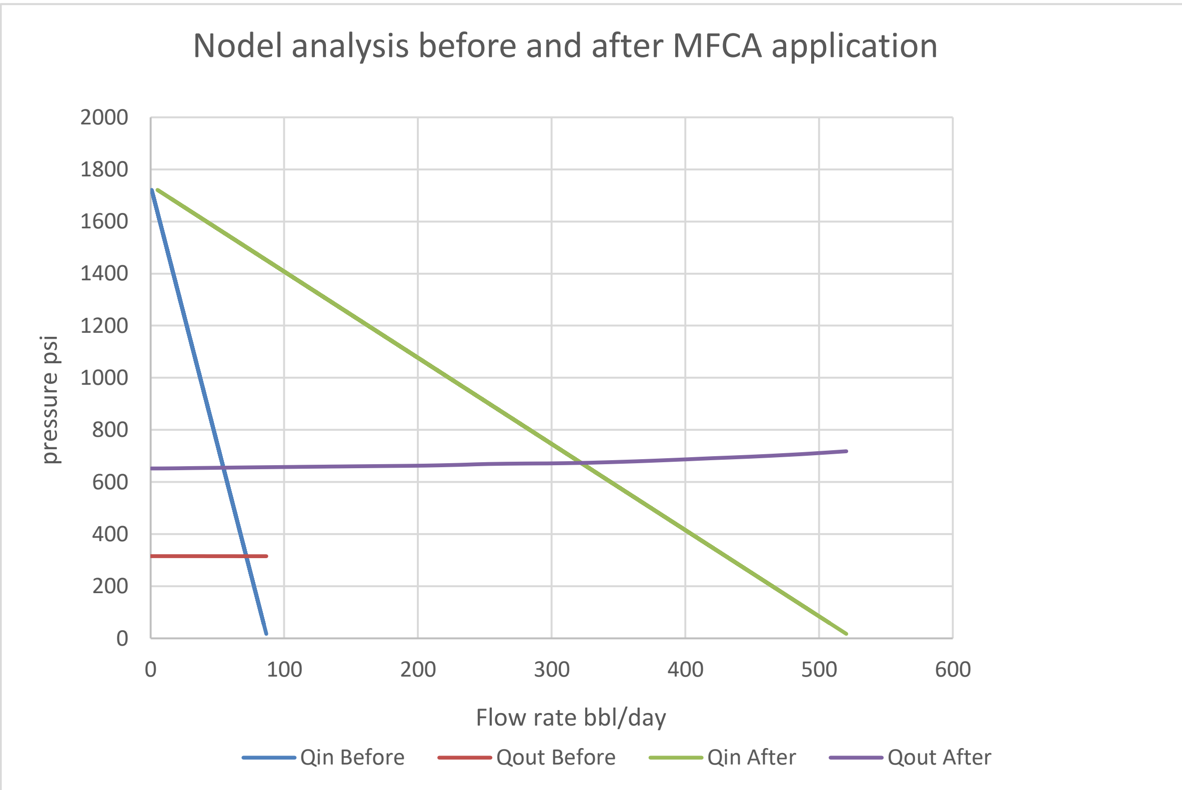
The following figures plotted by processing the received data from bamboo oil field in pipesim software .

The result of MFCA job shows there is improve in productivity of the wells due to reduction of skin around the wellbore and viscosity .

4.2 WELLS:

4.2.1 BBE-01

The IPR curve obtained from processing the data of BBE-01 Before and after using MFCA.



*From figure it found that the operation point was shifted from

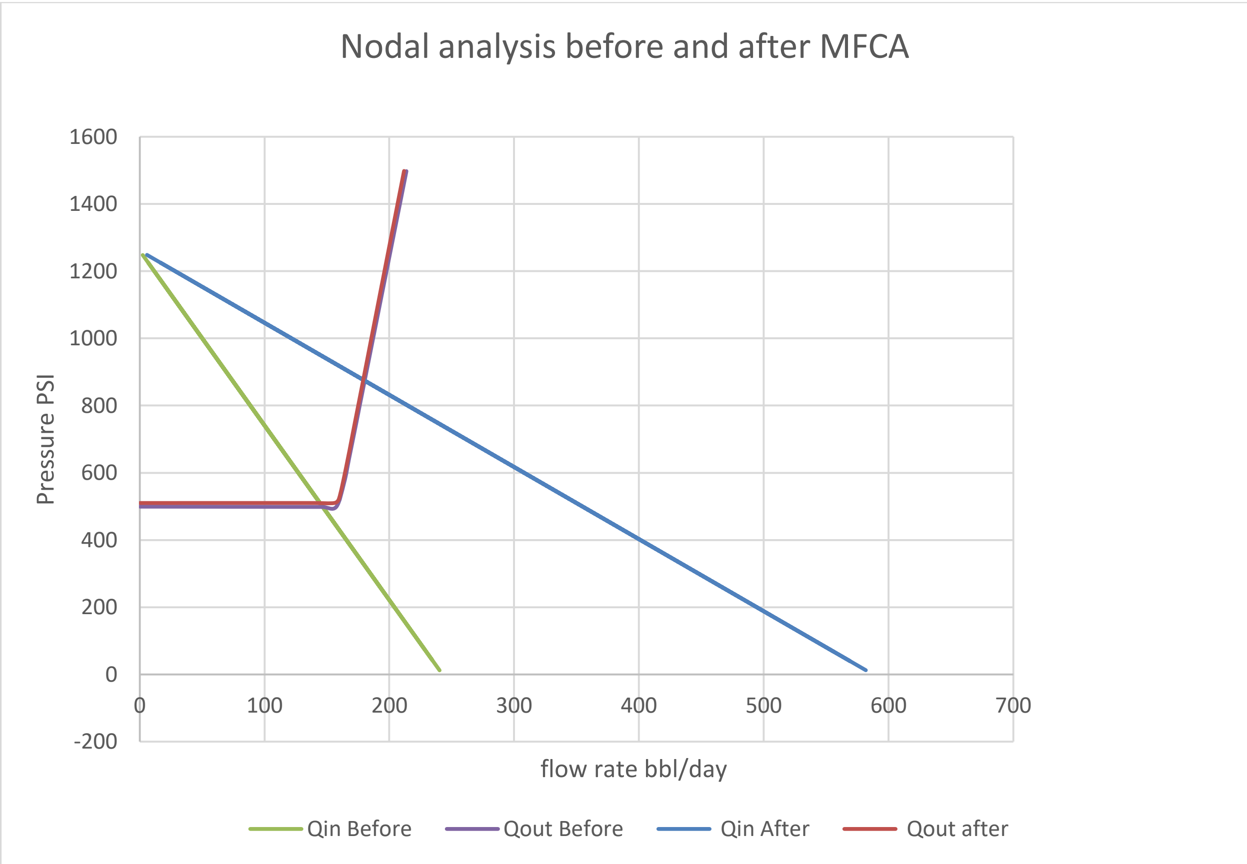
(77bbl/day) to (323bbl/day)

*Productivity index changed as follow

Productivity index	Before	After
Value	0.0503	0.30239

4.2.2 BBW-21

The IPR curve obtained from processing the data of BBW-21 Before and after using MFCA.



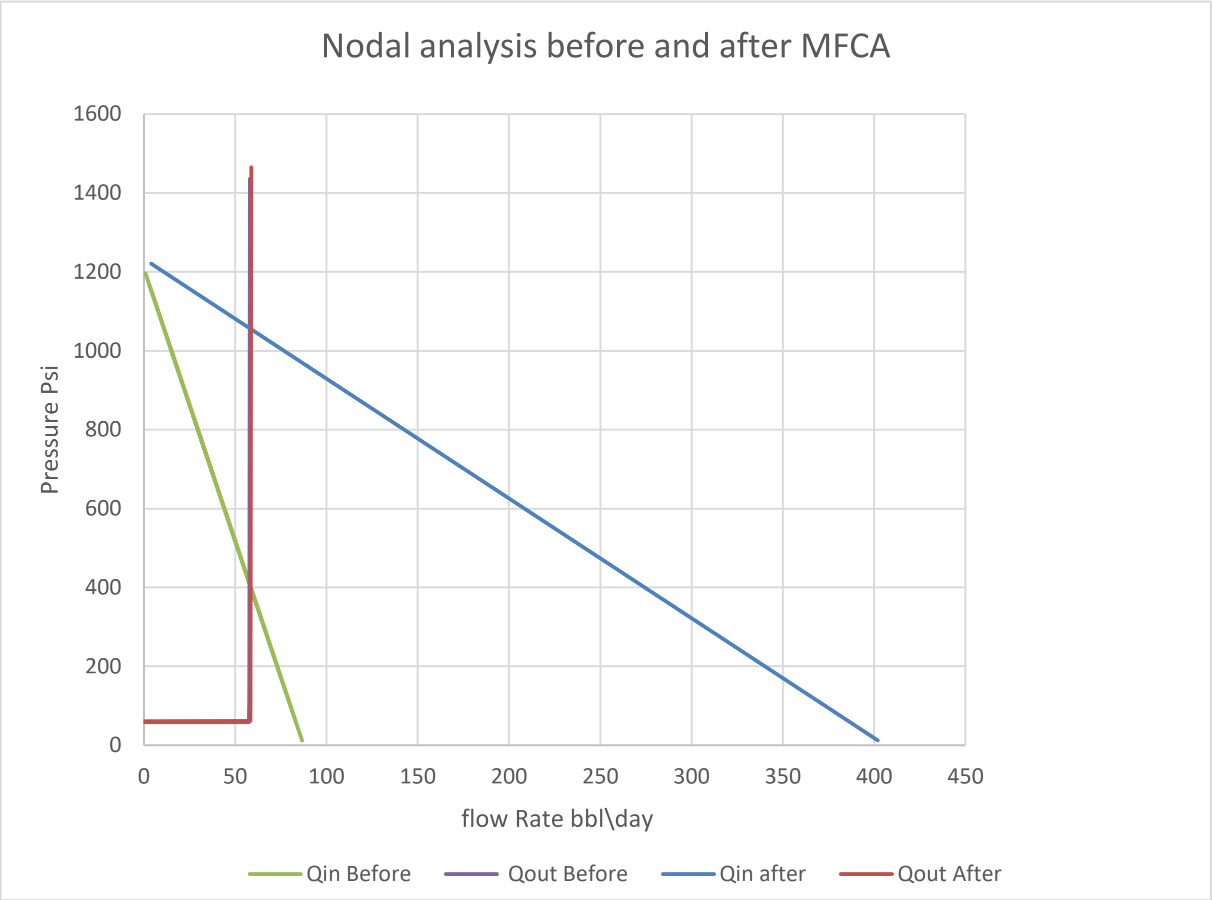
*From the figure it was found that operation point shifted from (140 bbl/day) to(179bbl/day)

*Productivity index change as fallow

Productivity index	before	after
value	0.072435	0.329325

4.2.3 BBW-54

The IPR curve obtained from processing the data of BBW-54 Before and after using MFCA.



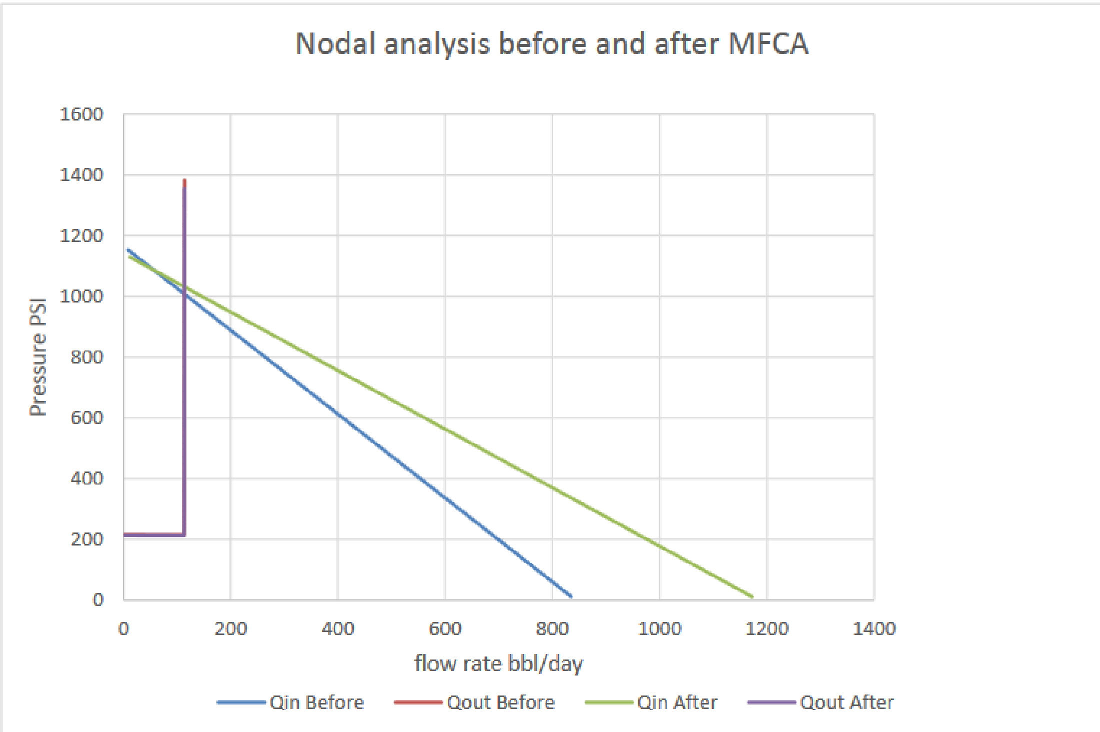
*From the figure it was found that operation point has not significantly changed to flow rate but the flowing bottom hole pressure increased significantly .

*Productivity index change as fallow

Productivity index	before	after
value	0.072435	0.329325

4.2.4 BBW-55

The IPR curve obtained from processing the data of BBW-55 Before and after Using MFCA.



*From the figure it was found that operation point has not significantly changed to flow rate but the flowing bottom hole pressure increased significantly .

*Productivity index change as fallow

Productivity index	before	after	
value		0.72424	1.037846

4.3 The effect of MFCA on viscosity for all Wells :

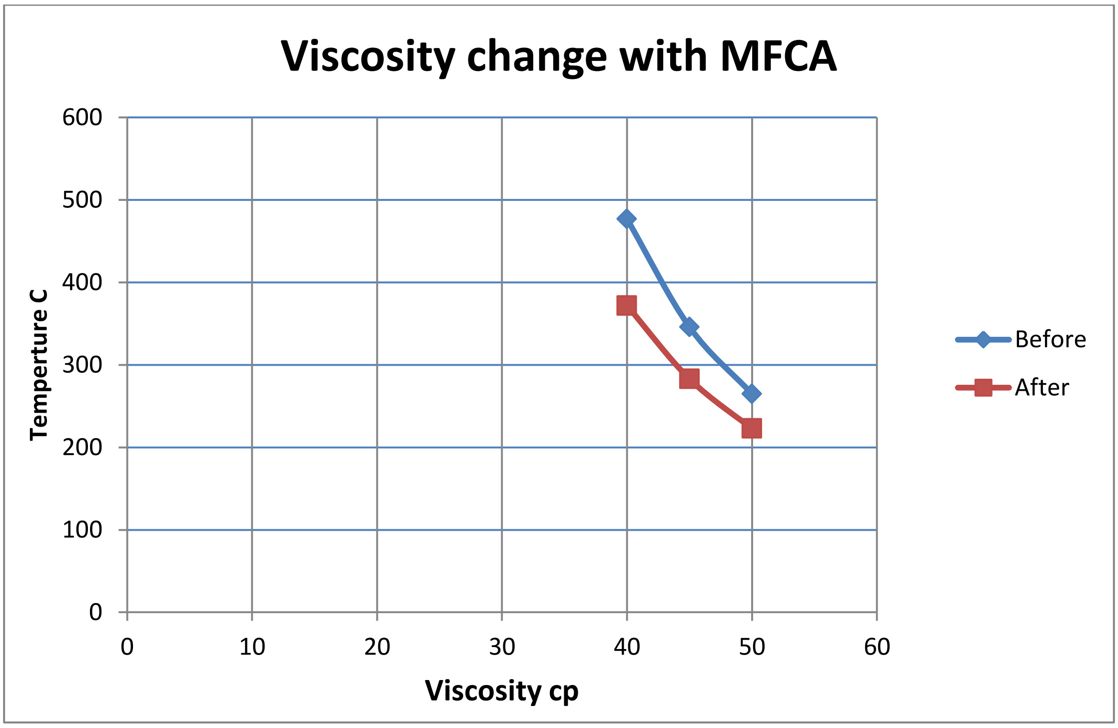


Figure 5 : shows that in the presence of MFCA we can have lower viscosities at the same temperature compared to the use of heating without MFCA, Which lower the energy used.

4.4 Lab tests for the wells after and before using MFCA:

Well name / Parameters	BBW-21	BBW-54	BBW-55
Temperature	33 – 39 °C	No change	No change
BS&W	Reduced	No change	No change
Viscosity	Decrease after MFCA	Increase after MFCA	Increase after MFCA
Shear rate	From 8 to 4	From 6 to 8	From 6 to 8

Chapter 5

Conclusion and Recommendations:

5.1 Conclusions:

This study is associated with formation damage and down-hole deposition effect on well productivity and oil viscosity. Based on stimulation results obtained from this study the following conclusion can be given about using MFCA in Bamboo oilfield:

- ✓ The MFCA has used as production stimulation agent and its objectives and properties have studied well and its effect on productivity is well defined.
- ✓ Data collection and analysis has been run into PIPESIM to determine the productivity of the wells before and after using the MFCA and its effect on viscosity.
- ✓ A plotting of the flow rate (before and after using MFCA) vs pressure was presented for 4 different wells using nodal analysis and the operation point was noticed for each well. The shift of operation point forward means there is a change in well productivity due to decrease in viscosity and the removal of skin.
- ✓ Through the four wells(BBE-1, BBW-21, BBW-54, BBW-55), two wells BBE-1 and BBW-21 have responded to the MFCA process and show good productivity because they have good reservoir conditions. BBW-21 have shown perfect respond to the operation and based on this well the following recommendation were presented.

5.2 Recommendations:

From the outcomes of the research, the following recommendations can be made:

1- When the productivity decrease stimulation job have to implemented to recover more oil.

2- Use the MFCA when The water cut : 30%-70%

3- Its highly recommended to conduct a detailed studies about the asphaltene in Bamboo oilfield .

4- This study focus only on the stimulation job of the field without considering the economic side in details , so its recommended to that incase a new study made , economic aspect can be taken into consideration with more details.

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