Scholars Journal of Engineering and Technology (SJET) **ISSN 2321-435X (Online)**
Sch. J. Eng. Tech., 2015; 3(3B):273-276 **ISSN 2347-9523 (Print)**
©Scholars Academic and Scientific Publisher
(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Research on the Mechanism of Viscoelastic Emulsion Flooding

Yazhou ZHOU[1], DaiyinYIN[1], Xiangkun BU[2], Chengli ZHANG[1]
[1]College of Petroleum Engineering, Northeast Petroleum University, Daqing, China
[2]The 8th Team in Logging & Testing Company of Daqing Oilfield Company Ltd, Daqing, China

***Corresponding author**
Yazhou Zhou
Email: zhouyazhou720@163.com

Abstract: Chemical flooding adopts polymer to realize flow control generally. But section inversion is serious in the late injection and polymer is easily to block oil layers, compounding the difficulty of chemical flooding. In-house research of ASP flooding and field text has showed that emulsification has a significant impact on oil recovery in chemical flooding. Based on the geological features and fluid characters of major blocks in Daqing oil fields, betaine emulsion with better emulsification ability were chosen to carry experience. The produced fluid scales of reservoir with different permeability were measured by adopting heterogeneous cores with different permeability variation coefficient. Mechanism of emulsion to improve swept volume was analyzed as well by comparing produced fluid characters of surfactant flooding. The study showed that for three layers heterogeneous cores with even permeability of 400 $\times 10^{-3} \mu m^2$ and permeability variation coefficient of 0.72, oil recovery of emulsion flooding is more than water flooding by 16.98% and fluid production of middle-low permeability layers is increased by 16%. And Emulsion flooding can control mobility, which can avoid channeling phenomenon in surfactant flooding; it can also push and shove to displace residual oil. It can adjust the profile and improve "fingering phenomenon".
Keywords: emulsion flooding, viscoelasticity, residual oil, emulsifier, large emulsion

INTRODUCTION

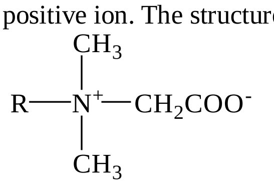
In China, chemical flooding has obtained good effect[1], but around the world, chemical flooding has poor effect, it results in the chemical flooding can not popularize in the worldwide. Currently, most polymer used in chemical flooding is HPAM (partially hydrolyzed polyacrylamide), it is sensitive to the salinity of formation water in particular Ca^{2+}, Mg^{2+} ion and reservoir temperature. With the increase of formation water salinity and temperature, the system of molecular chain rupture and its viscoelasticity fall sharply [2]. Furthermore, during polymer flooding field test in Daqing oil field, profiles inversion appeared at the later stage, then water cut rose quickly, the development effect became poor [3, 4]. In this paper, the displacement effect of emulsion flooding has been evaluated through contrasting to other chemical flooding method, displacement mechanism of emulsion flooding has been studied by microcosmic core. The research has a more clear understanding to the displacement mechanism of emulsion. It has important significance to displacement mechanism of chemical flooding, and plays an instrumental role in choice of chemical agent in field test.

EXPERIMENTAL CONDITIONS AND METHODS

Experimental reagents and equipment

Betaine type surfactant; Petroleum sulfonate; Sodium carbonate; HPAM, which molecular weight is 19 million, concentration is 1500 mg/L; Oil used in experiment is simulated oil, which mixs wellhead oil of Daqing oilfield with kerosene, its viscosity is 9.5 mPa·s (45˚C condition). Total salinity of injection water and formation water is 729.3 mg/L and 6578.0 mg/L. The displacement core is 30 cm × 30 cm × 4.5 cm artificial core. Microscopic displacement core is cemented by transparent acrylic plate and 50 mesh sand.

Glycine betaine is a kind of ampholytic surfactant, it is isolated from sugar beet by Kruger. The glycine betaine surfactant used is carboxyl group type; its molecule has two hydrophilic group that are negative and positive ion. The structure is:



Where, R is long carbon chain alkyl group or hydroxy group.

Main instruments: TX500D spinning drop interface tensiometer, ES-120 electronic analytical balance, Brookfield LVTDV III+ programmable rheometer, NDJ-4 viscometer, HW-4A double thermostat, ISCO pump, etc.

Experiment method

In this research, considering the formation mechanism of emulsion in the reservoir, middle core is connected before the displacement core. The permeability of middle core is the same as the displacement core. The emulsion is formed through middle core after injecting surfactant, then emulsion goes into displacement core. The microscopic displacement experiment device is shown in Fig.1.

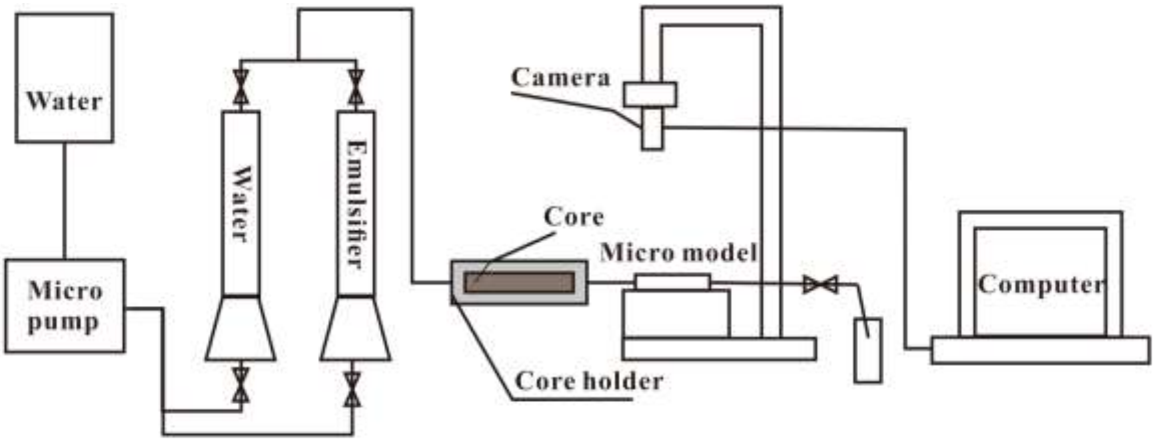


Fig.1. Micro-displacement device used in experiment

DISPLACEMENT EXPERIMENT RESULTS

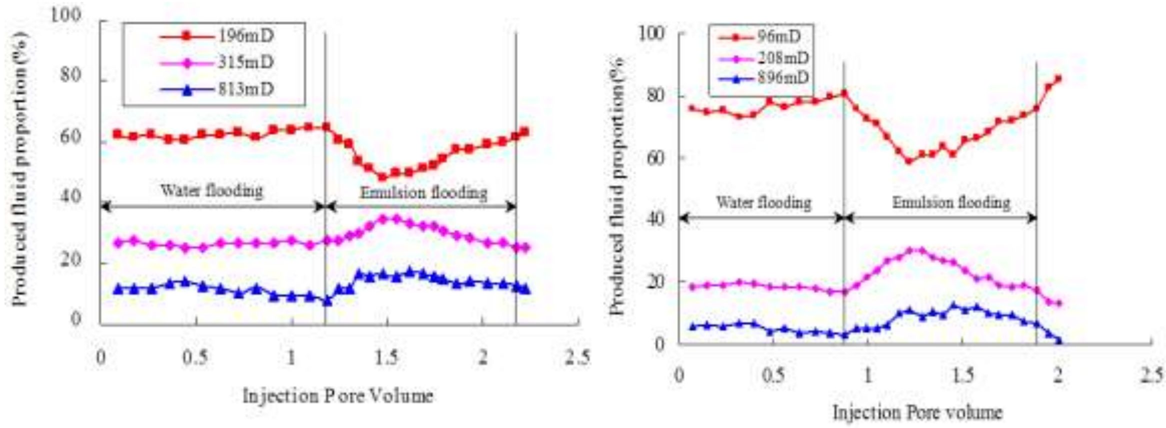
Using three tubes in parallel cores, we do a flooding experiment,which is under the conditions of the same average permeability (The average penetration rate is $400\times10^{-3}\mu m^2$), different permeability coefficients of variation in parallel heterogeneous core emulsion, Recording the change in the emulsion flooding high, medium and low permeability layers produced fluids, results in Table 1

Table 1 The results of of the parallel core flooding experiments

No.	Permeability coefficient of variation (PV)	Permeability ($10^{-3}\mu m^2$)	Recovery ratio(%OOIP)		
			Water flooding	Emulsion flooding	Total
1	0.2	285, 418, 479	44.19	12.87	57.06
2	0.41	205, 416, 623	41.62	14.56	56.18
3	0.72	196, 315, 813	38.35	16.98	55.33
4	0.88	96, 208, 896	35.67	17.72	53.39

From the experimental results, we conclude that the greater the permeability variation coefficient, the core vertical heterogeneity is stronger, the lower the water flooding recovery, but the higher the emulsion drive during recovery degree. Permeability coefficient of variation of the degree of recovery core emulsion flooding stage than the 0.88 coefficient of variation of 0.2, more than 3% of the rock.

Fig.2 is produced fluid proportion curve of different permeability core through parallel core experiments. When the permeability variation coefficient V_k is 0.72 and 0.88, compared with water flooding, in emulsion flooding, produced liquid ratio decreases by 16% and 21% in high permeability core, and increases by 7% and 9% in low permeability core. It can be seen that, the emulsion flooding can adjust liquid producing profile aiming at different vertical heterogeneous cores.



(a) V_k=0.72 (b) V_k=0.88

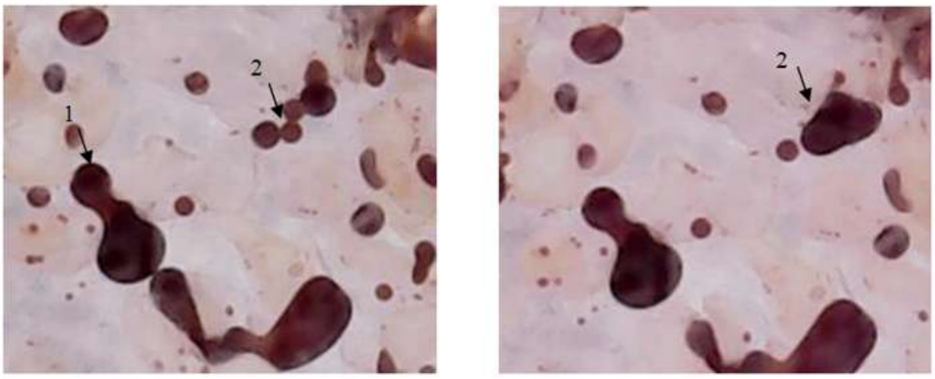
Fig-2: Produced fluid proportion curve of different permeability core

THE DISPLACEMENT MECHANISM OF EMULSION FLOODING

The displacement mechanism of emulsion flooding has been studied through microscopic visual displacement experiments. The microscopic visual displacement experiments

The microscopic visual displacement experiments show that:

(1) After water flooding, when injecting emulsion, due to oil-water interfacial tension lowers and local displacement pressure increases, residual oil is more easily to block and break up and forms the emulsion, as shown in position 1 columnar residual oil of Figure 3(a). The front edge of columnar residual oil separates from columnar residual oil, and starts to migrate and forms emulsion. And the emulsion size is nearly as big as the throat size, and even if the emulsion formed is smaller than the throat, the small emulsion is unstable, the small drops can coalesce into big drop in the process of migration. As the big drop viscosity is bigger than oil viscosity, the mobility is small, and furthermore, the big drop generates Jamin effect passing through the throat. The seepage resistance increases, and it makes the displacing fluid enter into the low permeability area.



(a) (b)

Fig-3: The emulsion migrates in the microcosmic core

(2) As shown in position 2 of Figure 3(b), smaller emulsion migrate and contact mutually in the core, interfacial film of smaller emulsion bursts, and smaller emulsion gather into large emulsion which is close to pore throat size. The larger emulsion will deform in the process of migration in the rock, they can go deep into blind ends pore. Under the displacement pressure, the migration of larger emulsion in the pore throat is equivalent to piston displacement closing to pore throat diameter. The elastic energy which is generated by deformation of emulsion can displace the residual oil.

(3) The changes of columnar residual oil in emulsion flooding are shown in Figure 4.

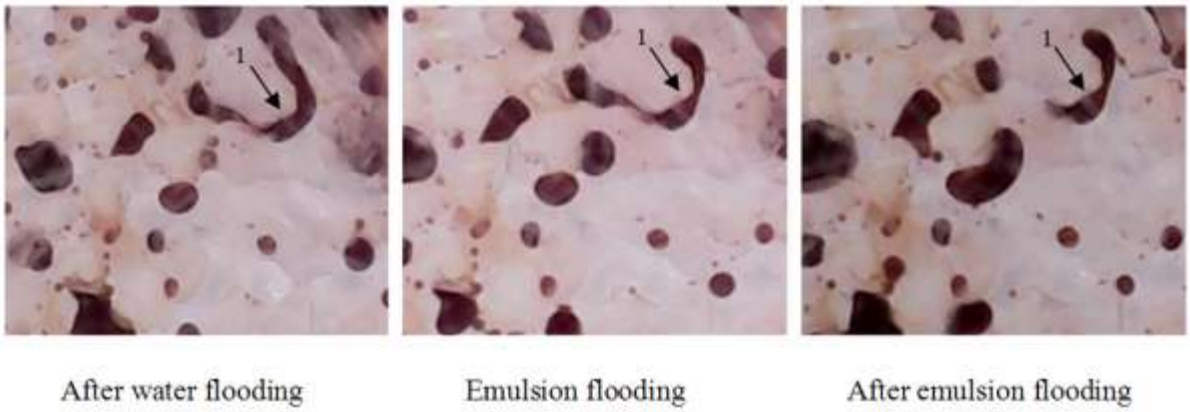


Fig-4: The change of columnar residual oil during the emulsion flooding

During water flooding, the injected water flows quickly along high permeability zone, small resistance or less residual oil area, the columnar residual oil is formed in position 1. In emulsion flooding, larger emulsion firstly blocks high permeability zone, and it forces the latter emulsion enters into the area of columnar residual oil. Due to reducing the interfacial tension and extruding of emulsion, columnar residual oil gradually breaks, becomes emulsion, and starts to migrate forward. After emulsion flooding, this residual oil reduced by 2/3.

CONCLUSIONS

(1) Emulsion flooding can control mobility, which can avoid channeling phenomenon in surfactant flooding; it can also push and shove to displace residual oil. It can adjust the profile and improve “fingering phenomenon”.

(2) Microscopic displacement experiments show that emulsion can displace the residual oil such as the blind end shape, columnar, clusters. It can lower interfacial tension, makes crude oil more easily to emulsify into emulsion and starts to migrate.

(3) Currently, the emulsifying property of emulsifier is not good enough. If it is good enough, it can form the emulsion which the size is large enough compared with the pore throat size of rocks, and the strength of interfacial film is large enough. Emulsion flooding can be a promising method to improve recovery with no polluting reservoir, and it can probably replace polymer flooding and ASP flooding.

ACKNOWLEDGEMENT

This work was supported by Graduate Students’ Innovative Research Projects of Northeast Petroleum University “Research on mechanism of micro-scale deformation emulsion in pore size level displacing residual oil after water flooding”(Grant No. YJSCX2014-009NEPU). And National Science Foundation “Microemulsion Percolation Mechanism and Numerical Simulation Study on Surfactant Flooding in Low Permeability Reservior” (Grant No. 51474071)

REFERENCES

1. Wang Demin, Wang Gang, Xia Huifen; Chemical Flooding Recovery Mechanism of Natural Cores[J]. Journal of Southwest Petroleum Uniwersity (Seience & Technology Edition), 2011; 33(2): 1-12.
2. Guillen VR, Carvalho MR, Alvarado V; Pore Scale and Macroscopic Displacement Mechanisms in Emulsion Flooding . Transport in Porous Media, 2012; 94(01): 197-206.
3. Abdul HJ, Ali SM; Combined polymer and emulsion flooding methods for oil reservoirs with a water leg[J]. Journal of Canadian Petroleum Technology, 2003; 42(2): 35-40.
4. McAuliffe CD; Crude-oil-in-water emulsions to improve fluid-flow in an oil reservoir[J]. Journal of Petroleum Technology, 1973; 25: 721–726.
5. Zhao Fenglan, Yue Xiang’an, Hou Jirui, Li Kai; Impact of Alkali on Emulsification of Compound Flooding System and Crude Oil. Drilling Petroleum Techniques, 2010; 38(02): 62-66.
6. Kang Wanli, Zhang Lidong, Wu Junzheng, Zhang Xuena; The displacement method Ⅰ of spontaneous emulsification: research on formula of spontaneous emulsification flooding. Journal of Oil and Gas Technology, 2005; 27(02):351-352.