P208 BIOPOLYMER FLOODING PILOT TEST IN HIGH VISCOUS OIL FIELD

CHENGZHI YANG[1], YUHUAI QIAN[1], ZHUHONG LOU [1], HONG YUAN[1], XIUNING LI[1], RENJUN LIU[2] and ZHICHENG ZHANG[2]
[1] Research Institute of Petroleum Exploration and Development, PO Box 910, Beijing 100083, China
[2] Shengli Petroleum Administrative Bureau

1. Introduction

Polymer flooding (Polyactrylamide) bas been successfally conducted in oil fields of China in recent years and on the basis of these pilot tests, the extend demonstration test and the commercial application has been carried out. These efforts and achievements have helped to for enhancing oil recovery and stablizing oil production in these oil fields.

In Gudong field of Shengli oil fields, Shandong province, because of the high viscosity of crude oil under reservoir condition and the high content of di-valent ions in the formation water, obviously, polyacrylamide flooding process is economically and technologilly not practical for operators.

Besides these advantages of biopolymer-Xanthan Gum with double spiral structure much as high enduring shear capacity, for insensitivity salt and multivalent ion and low adsorption on rock, the Xantham Gum developed is also thermally stable. Therefore, using Xanthan Gum as oil displacing agent in Gudong oil field will be more favourable than using polyacrylamide in terms of enhancing oil recovery of the oil field.

Based on the data of Gudong oil field, this paper presents the lab study results, including the physical and chemical properties of Xanthan Gum solution, the interaction between Xanthan Gum solution and reservoir rock, the results of oil displacing test and the numerical simulation calcalation and prediction on the basis of physical oil displacing simulation test. In addition, the pilot test plan of Xanthan Gum flooding is also designed based on the reservoir geological condition and the avaiblability of field facilities. This project has been put into effect since December of 1995 and the prelimary result is also presented in this paper.

2. A background of the pilot area

This pilot area is located at northern part of 7 block in Gudong oil field, Shandong province. Ther are 13 wells in the pilot area (4 injection wells, 1 center well and 8 producer). The well spacing is 150m, and the controlled area is 0. 29 km^2. The well location of the pilot area is shown in Fig. 1.

The testing target zone is $Ng\text{-}5^5$, its buried depth is 1297. 3-1309. 3m and formation temperature is 64. 4℃. The geological and fluid parameters of the reservoir are listed in Table. 1 and Table. 2.

Table. 1 Table 1. Geological Parameters in Xanthan Gum floodoingPilot test area

Parameters	Data	Parameters	Data
Depth, m	1297.3~1309.9	porosity of reservoir, %	34.0
Depth of the middle part of reservoir, m	1303.1	Air permeability, μm^2	1.339
Effective thickness, m	5.6	Dykstra—Parsons factor	0.65
Reservoir Temperature, ℃	64.4	Median grain size, mm	0.174
Total clay content, %	6.5	Sorting coefficient	1.48
Montmorillonite, %	37	Wettability of rocks	water-wet
illite, %	25.3	original oil saturation, %	60.3
Kaolinite, %	30.3	medianpore radius, μm	13.38
chlorite, %	7.4	potenticl pore, μm	18.85
carbonate minerates, %	0.9	rock compressibility, $10^{-10}Pa^{-1}$	46.9
		original formation pressure, MPa	12.8

Table. 2 Fluid parameters in Xanthan Gum flooding pilot test area

Parameters	Data	Parameters	Data
Underground oil viscosity, mPa • s	43.3	slinity of formation water, mg/l	12600
ground oil viscosity, mPa • s	288	$Mg^{2+}+Ca^{2+}$, mg/l	112
crude oil density, g/cm^3	0.9496	viscosity of formation water, mPa • s	0.45
oil-gas ratio, m^3/t	27.7	salinity of recycle sewage, mg/l	6477
volume factor of crude oil	1.0726	$Mg^{2+}+Ca^{2+}$, mg/l	131.6
oil saturation pressure, MPa	10.2	reinjection sewage pH	7.65

This pilot area was developed since June of 1986 and the water flooding was put into effect in July of 1987. The water cut is 90.4% and the recovery percent of reserves is 20% OOIP before the pilot test.

3. Evaluation of oil Displacing Agent and Implementation projet

3.1 Product Screening and solution property of Xanthan Gum

a. Xanthan Gum Product

3. 2 Flowing behaviour in porous medium and oil displacing efficiency of xanthan gum solution

a. Flowing behaviour and retention loss in porous media

Flowing test of Xanthan Gum solution is carried out in a sandpack filled by natural sandstone. The result indicates the solution showing a high resistance factor (RF) and a low remaining resistance factor(RRF) while flowing through cores. Also, the screen factor (SF) featuring its elastic viscosity is lower than that of PAM solution in the same test condition. The retention loss of Xanthan Gum is 70. 0 μg/g sand specifically and 68. 8 μg/g sand while flowing through porous media and through porous media saturated with oil.

b. Oil displacement efficiency

The physical simulation oil displacing test indicates that the oil recovery rate after water flooding can increase 18. 9% OOIP by using the injection system of 0. 1PV (0. 1% Xanthan)+0. 3PV(0. 15% Xanthan)+0. 1 PV(0. 1% Xanthan) (the viscosity of solution is 45 mPa. s), the benefite of Xanthan Gum is 299 t oil/t • Xanthan.

3. 3 mplementation project and prediction

a. Selection of Xanthan Gum oil displacement injection System

Six different injection systems (with combination of different concentration and injected volume of oil displacing agent and different slugs) are compared and screened based on the geological condition of the pilot test area.

The injection system listed in Table 5 is selected as the plan for the field pilot test.

Tahle. 5 Injection System Selected

Slug	Volume PV	Formalin %	Xanthan Gum %
Pre-flushing, I	0. 05	0. 2	/
Ahead protection, II	0. 1	0. 1	0. 1
main slug, III	0. 3	0. 1	0. 15
post protection, IV	0. 1	0. 1	0. 08
post protection, V	0. 05	0. 2	/

b. Injection rate

Considering the injectability and balanced between producer and injector flood during waterflooding in pilot test area, as well as the relationhsip between apparent viscosity (μ), shear rate(γ) and injection rate (v) of Xanthan Gum Solution while flowing through perous media, the injection rate in a single well is designed as 70m^3/d, which the injection pressure will be lower than the fracture pressure of reservoir and the oil displacing agent will be able to advancing speed uniformly in reservoirs.

3. 4 Current Status of field pilot test

The Chinese-made Xanthan Gum product and the production status of some major brands are listed in Table. 3:

Table. 3 Production data of some Chinese-made Xanthan Gum products

Manufacturer	Physical status of products	Producticity, T/Year
Keda Company, Hebei	broth	250
Runhua Biochermical company, Puyang	broth, dry powder	2000
Zhongxuan Biochemical company, Shandong	dry powder	500
Jinhu Biochemical plant, Jiangsu	dry powder	200
Xinhe Chemical plant, Hebei	dry powder	250

The total annual Xanthan Gum production capacity of China is over 5000 t, being able to require for the biopolymer flooding pilot test.

b. Viscosifying effect of Xanthan Gum

All the Xanthan Gum products can increase obviously the solution viscosity (Fig. 2). With a xanthan Gum concentration of 1500 mg/l, the viscosity of aqueous solution of different Xanthan Gum proudct ranges between 40. 5 to 45. 25 mPa. s, being 7~8 times as much of the viscosity of polycry lamide (PAM) aqueous soltuion with same concentration.

C. Stability of aqueous solution

Compared with PAM, Xanthan Gum aqueous solution is more chemically stable to both metallic ion and OH^-. The viscosity of Xanthan Gum aqueous solution tends to increase with the ionic strength (Table. 4), and keeps stable while PH=2~12, but, XH product flocculates in a sour environment. Xanthan Gum is poor in thermal ageing stability, but, KD product, is an exception. In the thermal aging test at 85℃ for over 10 months over 60% of the viscosity of KD aqueous solution can be retained(Fig. 3).

Table. 4 Relationships between viscosity of Xanthan Gum aquesus solution and ionic strengh

Products Brand \ Viscosity, mPa. s \ ionis Strength mg/l	0	1660	3320	6640	13280
KD	36. 4	43	43	45. 25	47. 5
XH	21	38. 5	40. 1	40. 5	41. 2

D. Injectivity of Xanthan Gum aqueous Solution

The Xanthan Gum aqueous solution Chinese-made brand is poorer in injectability and filtrability than flocon-4800 solution. However, after pre-filtering treatment, injectability can improved. In Gudong oil field however, no specific requirment to injectability of Xanthan Gum Solution because of the high permeability (>1. 2μm^2) of reservoir there.

The field pilot test started in 1995. The injection test is conducted firstly in two injectors. In December of 1995 after a balanced wellhend pressure of injectors were reached, the injection plan was put into effect. Up to December of 1996, the water cut in the pilot test area decreased 5.4%, the daily oil production is increased to 45.7t from 24.4t and an accumulated increase oil of 8559 t was obtained. The pilot test is now still in its way.

4. Conclusions

- Xanthan Gum is a more favourable oil displacement agent than polyacrylamide in heavy oil field and in the condition when the content of multivalent ions in recycle sewage is high.
- No reservoir plugging is ever encountered while using Chinese-made Xanthan Gum broth solution as oil displacement agent to enhance oil recovery.
- Xanthan Gum aqueous solution is of fine stability and so can be used as oil displacement agent to improve the sweep efficiency of oil displacing system.

References

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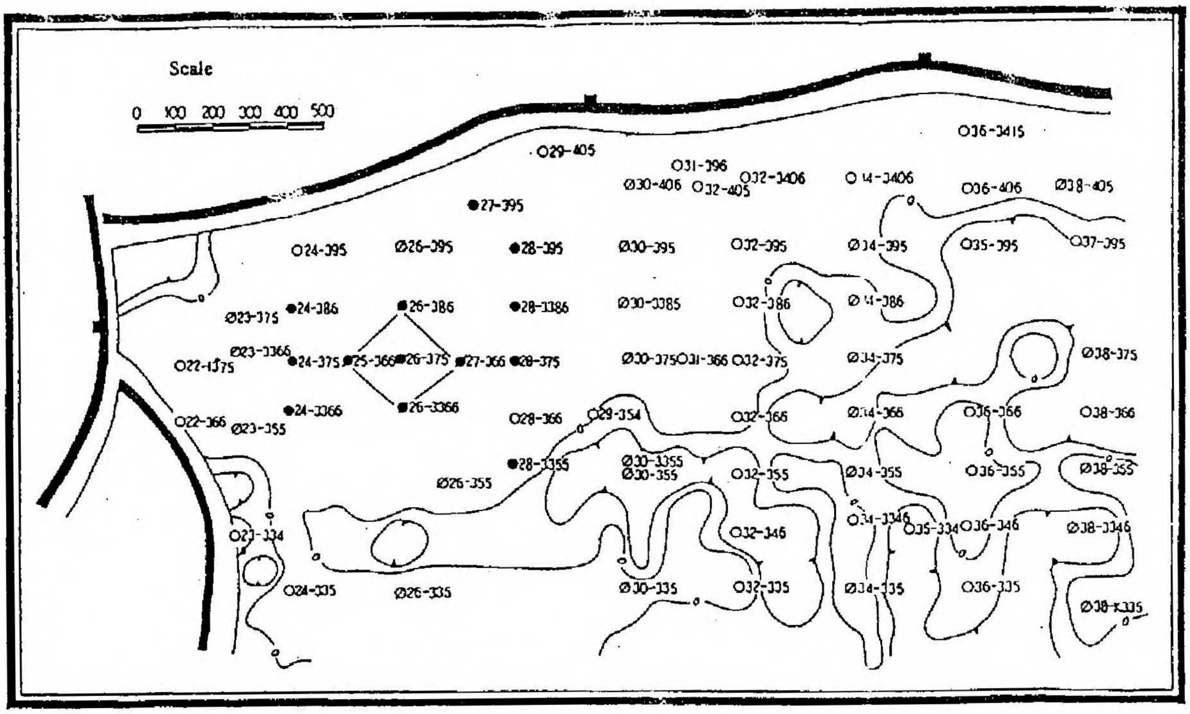

Fig. 1 Well location of the Xanthan Gum flooding pilot area

(Gudong oil field, Shandong province, China)

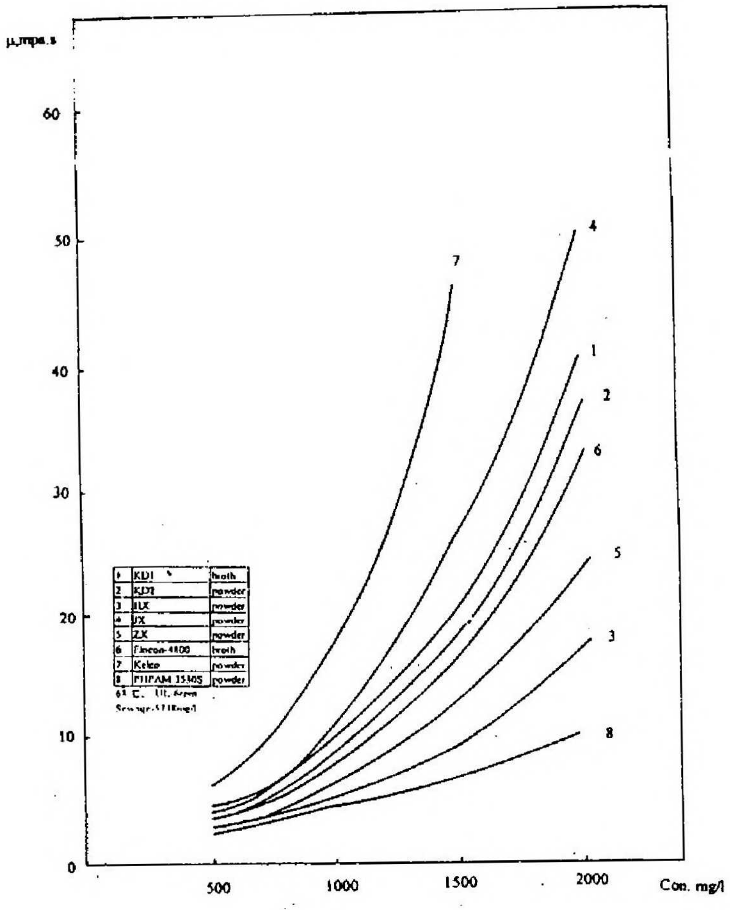

Fig. 2 Concentration Vs. Viscosity of Xanthan Gum

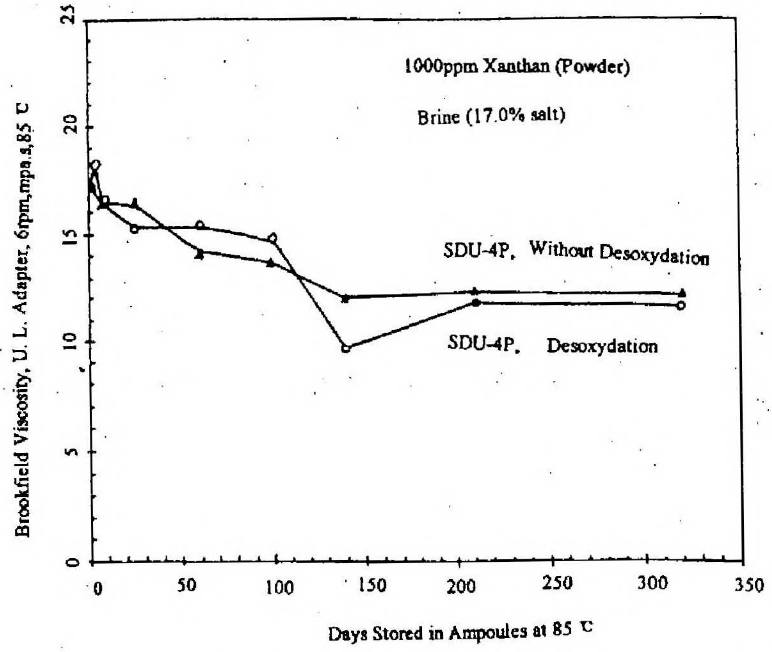

Fig. 3 Thermal ageing curve of Xanthan Gum aqueous solution