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The Experimental Study on the Compatibility Relationship of Polymer and Oil Layer

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Abstract: - This article is mainly about making indoor polymer flooding injection capacity experiment scheme, in view of the three groups of different permeability of artificial heterogeneous cores, selecting four kinds of molecular weight to make up the four kinds of concentration of polymer solution, and measuring the injection speed. According to oil layer injection ability boundary line delimitation, we give the polymer compatibility relations of different sedimentary microfacies oil layers in development zone. The research results can be used to guide select field polymer solution type, as to achieve the expected effect of polymer flooding.

Key words: *- polymer; injection speed; compatibility relations*

I. INTRODUCTION

Since 2002, the annual oil production of polymer industrial injection blocks in Daqing oil field keep in 10 ~ 15 million tons[1]. Polymer flooding is a technique of enhancing oil recovery, due to its inherent viscoelastic nature, producing tensile effect on the oil film or the oil droplets in the process of flowing, so improving the micro displacement efficiency, and polymer solution injection rate is an important parameter of effecting on the viscoelastic nature [2]. To provide actual development with the compatibility relation chart of the polymer injection parameters and the permeability, this article based on simulating formation pore structure and stress and carried out the following experiment.

II. EXPERIMENTAL MATERIALS AND SCHEMES

In order to ensure the accuracy of experimental results, first, measuring the viscosity of four different molecular and weight polymer solutions under the different concentrations, making polymer viscosity and concentration relational tables of clear water dispensing and waste water dilution. To solve the problem of compatibility of polymer injection rate, molecular weight, concentration and permeability of different sedimentary microfacies oil layers, in view of the physical characteristics of channel sand microfacies, the host phase microfacies and the non-host phase microfacies, designed the experimental scheme of three groups penetration level.

2.1 Materials and equipment

The experimental medicine: refining and chemical company production of the average molecular weight polymer powder of 12 million, 16 million, 19 million and 16 million

The cores in the experiment: 30 pieces artificial homogeneous cores.

The water in the experiment: working site sewage, clear water and indoor simulated formation water.

Laboratory equipment: constant pressure constant speed pump (gas voltage regulator), incubator, low-pressure intermediate container, sealed storage tank and pressure monitoring devices, core displacement device, produced liquid collecting device, monitoring recording equipment, filter unit, core evacuation saturation device.

2.2 The experimental scheme

According to the current development zone using injection system technology of clear water dispensing mother liquor and waste water dilution and statistical analysis the average permeability of different sedimentary

microfacies oil layers cores, designed the experimental scheme of three groups penetration level of the 300md, 500md and 750md, pressure gradient of 0.13 MPa/m constant pressure injection, selecting four kinds of the average molecular weight polymer powder of 12 million, 16 million, 19 million and 16 million, and making up four types of polymer solution concentration of 1500 mg/L, 2000 mg/L, 2500 mg/L and 3000 mg/L for indoor core injection capacity experiment.

2.3 The experimental process

1) Prepared with clear water dispensing the polymer solution concentration of 5000 mg/L, sewage dilution to the required concentration.

2) Made the artificial core vacuum and then saturated water after 8 hours.

3) Using constant pressure device with the pressure gradient of 0.13 MPa/m to make polymer solution inject into the cores, according to the liquid quantity of core displacement experiment records, and calculating the instantaneous velocity of the polymer in core, convert into formation velocity.

III. RESULTS ANALYSIS

3.1 The test results of relationship between viscosity and concentration

According to the working site production situation, measuring the relationship between viscosity and concentration of different molecular weight polymer solution of 12 million, 16 million, 19 million and 16 million, and get the polymer relationship between the viscosity and the concentration of clear water dispensing and waste water dilution, test results are shown in table 1.

average molecular weight(million)	Polymer concentration （mg/L)	1000	1200	1500	1600	1800	2000	2500	3000
12	viscosity (mPa.s)	18.9	26.4	32.6	35.6	50.6	62.4	142.8	256.7
16		23.4	30.1	39.6	45.2	63.7	87.4	169.1	302.5
19		26.7	34.8	48.2	54.3	74.1	102	201.4	365.2
25		36.8	45.2	75.8	87.6	121.4	158.7	336.4	486.7

Table1 The polymer relationship between viscosity and concentration

We can draw the following conclusions from the table 1: when the polymer molecular weight is constant, the viscosity increases gradually with the increase of solution concentration; when the solution concentration is constant, the polymer viscosity increases with the increase of molecular weight.

3.2 The results of polymer flooding experiments

Enumerate part of the polymer solution of clear water dispensing and waste water dilution advance speed variety curve chart of artificial cores, and investigating the 12 million and the 19 million polymer molecular weight injection rate law under the condition of the permeability of 300mD and 500mD and different concentrations.

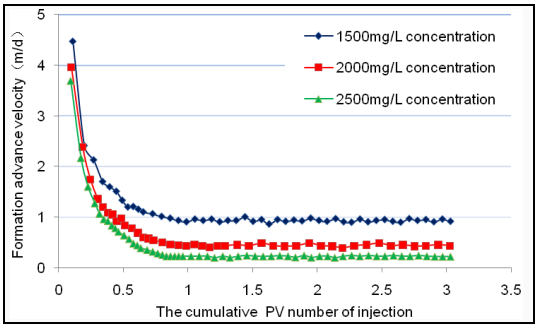

Fig.1 12 million molecular weight and 300md permeability

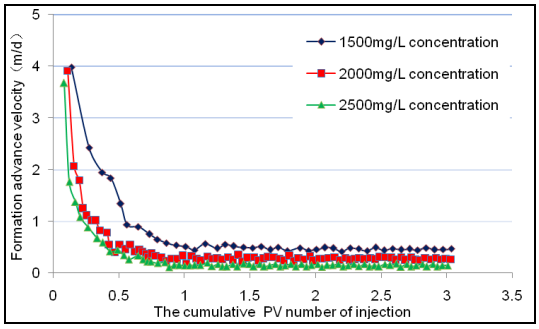

Fig.2 19 million molecular weight and 300md permeability

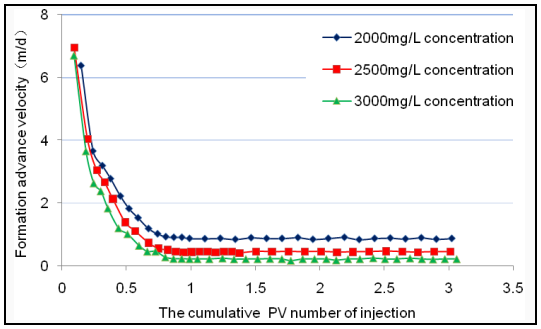

Fig.3 12 million molecular weight and 500md permeability

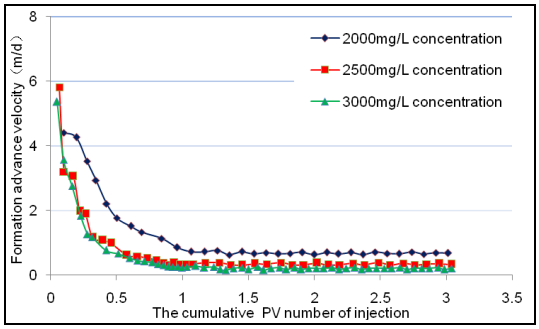

Fig.4 19 million molecular weight and 500md permeability

We can draw the following conclusions from figure 1 ~ figure 4: under the condition of constant pressure and the same molecular weight of polymer and permeability, the injection rate declines with the increase of polymer concentration. The table 1 shows that the polymer solution viscosity increases with the increase of solution concentration, so the injection rate declines.

Polymer molecular weight is one of the main factors influencing the polymer flooding effect. Contrasting figure 1 and figure 2, figure 3 and figure 4, under the condition of the same polymer concentration and permeability, the injection rate decreases with the increase of polymer molecular weight. The higher the molecular weight, viscosity increasing effect is better, but the injection effect is poorer; if the molecular weight is too small, the injection solution viscosity will not be able to effectively increase, the oil displacement effect is poor.

Comparing figure 1 and figure 3, figure 2 and figure 4, under the condition of the same polymer molecular weight and solution concentration, the injection rate increases along with the increase of the core permeability. Statistical analysis the core mercury injection data of the development zone, the pore throat radius increases with the increase of permeability and the correlation is good, therefore with the increase of permeability, the polymer solution can enter the more pore throat volume, the injection ability enhancement.

3.3 The analysis of polymer flooding core experiment

Based on the study results of three indoor experiment schemes, preliminary polymer injection capacity evaluation chart is given, the results are shown in table 2.

permeability (mD)	concentration (mg/L)	core injection rate（m/d）			
		12million	16million	19million	25million
300	1500	0.93	/	0.45	0.35
	2000	0.45	0.38	0.27	0.15
	2500	0.23	0.20	0.14	/
500	1500	/	/	/	0.40
	2000	0.87	/	0.65	0.22
	2500	0.45	0.41	0.34	0.11
	3000	0.22	/	0.20	0.05
750	2000	/	/	0.98	0.63
	2500	0.87	/	0.70	0.48
	3000	0.71	0.65	0.59	0.33

Table2 The compatibility relation chart of polymer injection rate, molecular weight, concentration and permeability

The following conclusions can be made from the table 1, for the polymer system of 12 million average molecular weight in the three permeability level experiments, injection ability is stronger, along with the increase of the concentration, 300md core experiment seepage velocity is 0.23-0.93 m/d, 500md core experiment seepage velocity is 0.22-0.87 m/d, 750md core experiment seepage velocity is 0.71-0.87 m/d; for the polymer system of 19 million average molecular weight, under the condition of the same concentration, in the injectivity capability of three permeability levels are less than 12 million average molecular weight polymer, 300md core seepage experiment velocity is 0.14-0.45 m/d, 500md core experiment seepage velocity is 0.20-0.65 m/d, 750md core experiment seepage velocity is 0.59-0.98 m/d; for the polymer system of 25 million average molecular weight, under the condition of the same concentration, compared with the polymer system of 19 million average molecular weight, the injection capacity is further reduce.

IV. INJECTIVITY BOUNDARIES AND APPLICATION

Based on the development zone actual injection condition, and combining the indoor artificial core seepage experiment results of clear water dispensing and waste water dilution polymer solution system, giving the oil layer injection capability boundaries:

1) more than 0.3m/d means the injection ability is high;

2) 0.3-0.2 m/d means the injection capacity is medium;

3) less than 0.2 m/d means the injection ability is poor.

For the injection of polymer, laboratory data showed that the cyclotron radius of polymer molecules must be less than 1/5 of the pore channels radius, or polymer solution will block up the oil layer pore channel [3]. According to this calculates the polymer molecules effective cyclotron radius value of corresponding to different pore radius median.

Referring to the experiment results of table 2, and combining the average permeability of the development zone different sedimentary microfacies oil layer cores, giving the preliminary compatibility relation of polymer injection parameters, as shown in table 3(italics mean injection capability is strong, normal font mean the injection capacity is medium).

sedimentary microfacies	pore radius median （μm）	the radius of polymer molecule cyclotron （μm）	permeability（mD）	allowable concentration （mg/L）			
				12 million	16 million	19 million	25 million
channel sand	4.64	0.928	610	*2500* 3000	*2500*	*2500* 3000	*1500* 2000
host phase	7.42	1.484	784	/	/	*3000*	*2500* *3000*
non- host phase	3.97	0.794	381	*2000* 2500	*2000* 2500	*1500* 2000	*1500*

Table3 The compatibility relation chart of polymer and sedimentary microfacies oil layer

Polymer stretch level and the additional pressure drop of after stretching increase along with the increase of speed, but the rate of shear would be greater when polymer solution enters into the oil layer, so when the injection rate is greater than a certain value, the viscoelastic effect will reduce, and affecting polymer flooding effect. But if the injection speed is lower, the elastic effect of the polymer molecules is smaller, the underground retention time and the production time will be longer. So we should departure from the actual conditions, and determine the best injection rate through the economic analysis [4].

V. CONCLUSION

In this paper, combined with the experimental results of three sets of project and the different sedimentary microfacies in the development zone of polymer injection parameters compatibility relations research, we can draw the following conclusions:

1) Under the condition of constant pressure: under the condition of the same molecular weight of polymer and permeability, injection rate declines with the increase of polymer concentration; under the condition of the same polymer concentration and permeability, injection rate declines with the increase of polymer molecular weight; under the condition of the same polymer molecular weight and concentration, injection rate increases with the increase of core permeability.

2) For different sedimentary microfacies in development zone: the channel sand microfacies match with the polymer solution of medium concentration and medium molecular weight; the host phase is suitable for the polymer solution of high concentration and larger molecular weight; the non-host phase is suitable for the polymer solution of lower concentration and medium molecular weight.

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