Study on preferred method of optimizing polymer molecular weight

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Abstract: In this paper, a new method is proposed to optimize the molecular weight of polymer based on the analysis of the influence of polymer molecular weight on oil displacement, which is by using the method of the pore volume, the parameters of polymer flooding and permeability, the numerical simulation. Not only the pore size of polymer molecules was considered, but also the matching of polymer molecular weight and permeability has been taken into account, Simulation of single molecular weight and different molecular weight optimal combination is carried out, and the results show that the method can improve polymer flooding effect by enlarging the sweep volume, and improve the economic efficiency of polymer flooding too.

Introduction

The effect of polymer flooding is not only related to the geological conditions of the reservoir, but also one of the important factors affecting the polymer flooding effect. The molecular weight of polymer plays an important role in polymer flooding.

Polymer flooding is to increase oil recovery by increasing the viscosity of injected water and decreasing the permeability of water phase. The molecular weight of polymer is one of the main parameters that affect the above mechanism. The higher molecular weight of the polymer, the better the viscosity, and the stronger the ability to reduce the water permeability[1]. The results of physical simulation experiments show that the higher the molecular weight of the polymer is, the higher the recovery rate is . The results show that when the polymer concentration is 1000mg/L, the molecular weight of the polymer is 5 million, the viscosity is 17mPa.s and the residual resistance coefficient is about 1.8,while when the molecular weight of the polymer is 17 million, the viscosity is 47mPa.s and the residual resistance coefficient is about 4.6 ,and the enhanced oil recovery up to 18.5% (Tab.1).So, the dosage of high molecular weight polymers is less than that of low molecular weight polymers. And the higher of enhanced oil recovery.Therefore, Due to the price is close of different molecular weight,in the case of geological conditions and injection conditions permission, a high molecular weight polymer should be choosen, in order to achieve better effect of polymer flooding under the same conditions.

Tab.1 Residual resistance coefficient and oil recovery of different molecular weight polymers

molecular weight (million)	concentration (mg/L)	viscosity (mPa.s)	Residual resistance coefficient	enhanced oil recovery (%)
5	1000	17	1.8	10.6
10	1000	33	2.4	14.3
17	1000	47	4.6	18.5

Method Of How To Optimize Polymer Molecular Weight

Optimization of the molecular weight with inaccessible pore volume. When the polymer solution flows through the porous medium, it is naturally chosen by the pore throat size of the rock , In this paper, the boundary occupied bound water pores as polymer molecules do not enter the molecular size to IPV=Swi(inaccessible pore volume is shorted for IPV)corresponding to the water as the compatibility of polymer molecules and rock and pore throat size[2].

With the increase of the molecular size and molecular weight of the polymer, the IPV increases almost linearly(Fig.1). The size of IPV reflects the compatibility of polymer molecules and pore throat size. The rock permeability is certain, if molecular size selection is too large, the liquidity clew is poor, easily trapped in a narrow channel at the residence, around injection wells polymer mechanical trapping volume increases, the loss in the early polymer injection process,fhe injection efficiency and the effectiveness of the polymer in the oil reservoir are influenced[3],Instead, if the molecular size is too small, the polymer viscosity is low, and the solution is easy to follow the large pore flow in the high permeable layer.

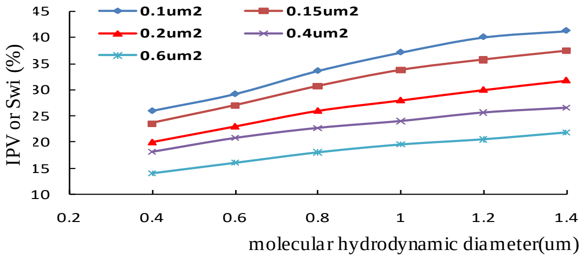

Fig.1 Relationship between molecular hydraulic diameter and IPV of different permeability reservoirs

Using the figure 1, we could select the molecular hydraulic diameter of different permeability reservoir and different pore volume,then the molecular hydrodynamic diameter was added to the molecular weight in Figure 2.For example,oilfield A, Swi=26.05%, so IPV=26.05%, permeability=0.2um2, In Figure 1, the molecular hydrodynamic diameter of the block is 1.0um, The molecular hydrodynamic diameter 1.0um was added to figure 2 and the molecular weight was 1200 x 104.

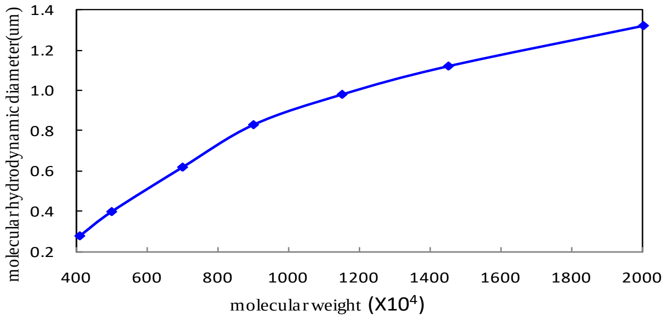

Fig. 2 Molecular hydrodynamic diameters of polymers with different molecular weights

Optimization of the molecular weight with reservoir properties and polymer parameters . In order to ensure that the polymer system has good matching with the oil layers with different permeability levels[4], according to the relationship between polymer flooding parameters and reservoir properties(Tab.2), reservor with Permeability of 0.1um2 can be injected into the polymer system of 7 million molecular weight, concentration less than 1500mg/L.and reservor with Permeability of 0.3um2 can be injected into the polymer system of 25 million molecular weight, concentration less than 2000mg/L. For example,oilfield A, permeability=0.2um2, In Tab2, the highst molecular weight was 1700 x 104.the highest concentration was 2000mg/L.

Tab.2 Relationship between polymer flooding parameters and reservoir properties

permeability	concentration	molecular weights($x10^4$)			
(μm^2)	(mg/L)	700	1200	1700	2500
0.05	1000	difficult	difficult	blocking	blocking
	1500	difficult	blocking	blocking	blocking
	2000	blocking	blocking	blocking	blocking
0.1	1000	easy	able	difficult	blocking
	1500	able	difficult	difficult	blocking
	2000	difficult	difficult	blocking	blocking
0.2	1000	easy	easy	able	able
	1500	easy	able	able	able
	2000	able	able	able	difficult

permeability (μm^2)	concentration (mg/L)	molecular weights($x10^4$)			
		700	1200	1700	2500
0.3	1000	easy	easy	easy	easy
	1500	easy	easy	easy	able
	2000	easy	easy	able	able

Optimization of polymer molecular weight by numerical simulation.

1. Mathematical model of polymer molecular weight.The viscosity curves, pore volume, molecular adsorption and shear parameters are mainly considered.

viscosity curve: $\mu_p^0 = \mu_w \left(1 + \left(A_{p1}C_p + A_{p2}C_p^2 + A_{p3}C_p^3\right)C_{SEP}^{S_p}\right)$ (1)

rheological characteristics: $\mu_p = \mu_w + \dfrac{\mu_p^0 - \mu_w}{1 + \left(\gamma / \gamma_{ref}\right)^{p_\alpha - 1}}$ (2)

Permeability decreasing coefficient : $R_k = 1 + \dfrac{\left(R_{KMAX} - 1\right)b_{rk}C_p}{1 + b_{rk}C_p}$ (3)

2. Numerical simulation of polymer flooding with different molecular weights. The effect of different molecular weight on polymer flooding was predicted by the injection concentration 1200mg/L, injection rate 0.2PV/a and polymer dosage 1200mg/L.PV. From the numerical simulation results, with the increasing of molecular weight, the lower the value of water cut, the higher the stage of water cut, the higher the stage of recovery(Tab.3), but the lower the injection ability.

Tab. 3 Prediction of polymer flooding effect with different molecular weights in oilfield A

molecular weights ($x\ 10^4$)		The end of polymer flood			water content 98%	
		water content (%)	stage Oil-producing (10^4t)	Stage recovery (%)	stage Oil-producing (10^4t)	Stage recovery (%)
Water flood					7.57	1.16
Single polymer	1900	96.42	66.44	10.18	77.53	11.88
	700	96.18	67.48	10.34	78.58	12.04
	2500	95.74	69.44	10.64	80.15	12.28
polymer combination	2500+1900	96.01	61.15	9.37	71.60	10.97
	2500+700	95.81	64.74	9.92	77.53	11.88
	2500+1900+700	96.59	62.33	9.55	70.81	10.85

Considering the injection condition in the actual injection process, different molecular weights are combined in the same injection parameters.From the results of numerical simulation , Combination of 25 million and 7 million molecular weight will get the highest recovery.

Conclusion

(1) The pore volume of the reservoir can be determined by the water saturation, and the molecular weight of the polymer can be determined according to the molecular weight hydraulic diameter of the pore volume of different permeability reservoirs.

(2) The relationship between polymer flooding parameters and reservoir properties can not only determine the molecular weight of polymer, but also optimize the concentration of polymer.

(3) Numerical simulation not only can be used to optimize the single molecular weight of polymers,but also can optimize the best combination of different polymers

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