Experiment Research of Microbial Flooding Injected Capacity and Injected Volume

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Abstract. Strains of microbial enhanced oil recovery technology is the use of crude oil directly in growth and the same time the metabolites of itself, so as to enhance oil recovery. Experimental study on paper through a number of data analysis. The growth and metabolism of three kinds of oil producing bacteria in the core are determined, and the corresponding growth curve is obtained. The parameter sensitivity analysis of the microorganism flooding process by homogeneous core is studied, and the influence of injection capacity and injection volume on the oil displacement effect is studied. The same permeability, water, temperature and other conditions, microbial injection pressure has a certain degree of increase than water flooding. Injection volume depends on the actual input-output ratio, quantity is 0.3PV is more reasonable.

1. Introduction

Since its Beckmann suggests that microbes could be used for enhanced oil recovery, after nearly a century of practice and study microbial enhanced oil recovery technology will continue to improve, gradually entered the scientific field in oil [1]. MEOR has the following advantages: oil displacement mechanism of unique, simple operation process, the characteristics of no harm to the formation and environment, as well as the selection of microbes and nutrient solution is determined by the formation environment, so caused the attention of microbial technology in the world, and in-situ practice widely, and achieved very significant to improve oil recovery effect. Especially, for benefit less well, has a very significant role in extend the economic life of the well [2, 3].

Although in practice and theory research of microbial enhanced oil recovery technology achieved excellent results, there is still a lack of biological characteristics of microorganisms. Therefore, in the later practice and theoretical study, we should constantly improve the technology; strive for maximum microbial enhanced oil recovery technology to play role in enhanced oil recovery.

2. Study on growth regularity of microorganism in porousmedium

2.1. Experimental material

Experimental Water: according to JQ water salinity of formation water in the preparation of simulation,
Experimental core: Daqing oil field natural core-JQ model,
Experiments using micro-organisms: bacteria Ns4, Ns8 and Wp1, concentration of 3%.

2.2. Experimental Steps

a. A certain amount of bacteria and nutrient solution injected into the JQ model 35 ℃for culture.

b. Every certain amount of time, injecting into a volume of culture bottle, regular analysis the core effluent sampling, calculating the number of bacteria.

c. Take time as abscissa, logarithmic in the number of ordinates of the bacteria, draws a half-logarithmic growth curve.

d. Analysing the growth curve, determining the microbial growth phase and growth.

2.3. Experimental results and analysis

Based on the Figure 1~3 , the growth curve of bacteria can be divided into four stages: adaptation period (adjustment), exponential phase (period of vigorous growth), stability (balance), aging (death). The four stages of Ns4, Ns8 and Wp1 growth have its own characteristics:

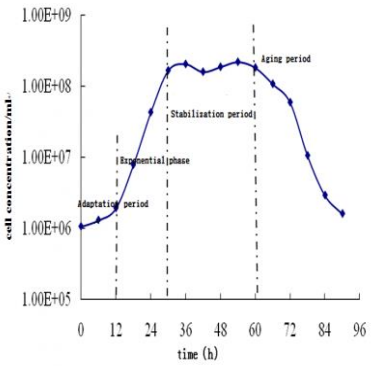

Figure 1 Ns4 Growth curve of JQ model

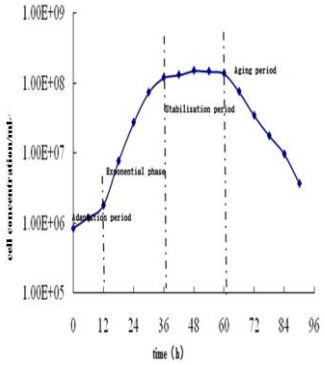

Figure 2 Ns8 Growth curve of JQ model

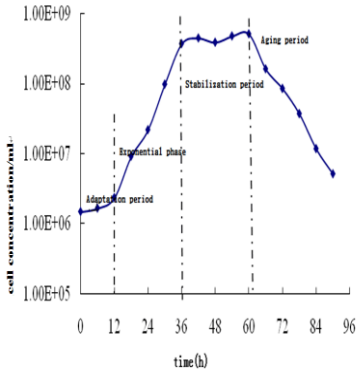

Figure 3 Wp1 Growth curve of JQ model

a. Adaptation period also known as the period of adjustment. After bacteria and nutrient solution inject model, it occurs a period of slightly reduced the number of thalli, or hardly ever increasing phenomenon. It shows strain Ns4, Ns8 and Wp1 will need some time to adapt to the JQ model environment. During this period, the bacteria hardly reproduces, because the model has adequate carbon sources, nitrogen sources and moisture, bacteria absorb nutrients, so this period of time we called adaptation [4]. This period is sensitive to external factors, the resistance is not strong, easily inhibited by high temperature, low temperature solution or even death. Length of the adaptation period depends on the factors which are the age of the strains, environment and so on. Different bacteria

species and genes, length of the adaptation period is different. JQ Model has a great influence on the adaptation period of strain Ns4, Ns8 and Wp1. The adaptation period is longer and it is about 12h.

b. Exponential phase, also known as the period of vigorous growth. After a period of adaptation of the bacteria, strain reaches top speed for breeding and bacteria increases exponentially. During this period, bacterial physiology and morphology are consistent and metabolic capacity is the most exuberant [5]. At the same time, the generation time is shorter and more resistant to the outside world, or not with the death of the bacteria. But the growth of the bacteria multiply rapidly at this stage need to consume large quantities of carbon source and nitrogen source, so experiment continued supply of culture. The period of vigorous growth is about 12 hours.

c. Stabilization period also known as the plateau. This stage is characterized by a cell after multiply by the number, cell number reaches the maximum value, food is consumed in the model, metabolites begin to accumulate [6] .When a new cell number and dead cell number almost equal when it entered a period of stability. Training 36h, metabolites of reproduction-bio-surfactant and bio-polymer gradually reaches the maximum value. The stabilization period of strains is short for 18h in the JQ model. During the stable period, per unit volume than cell number of thalli of Wp1 has an order of magnitude the number of others, and Wp1 has most metabolites. Therefore, the microbial displacement experiment in the process, strain into the model, constant place 48h of subsequent water flooding experiment.

d. Aging period, also known as death. This stage mortality rate is greater than the growth rate of the bacteria, metabolism is no longer increasing.

3. Study on microbial injection capacity

3.1. Experimental steps

a. constant temperature box temperature 35 ℃, core models for taking 4H, JQ saturated block of simulated water, place 8h,

b. Water permeability cores, use JQ simulating water with 0.3mL/min water flooding experiment of speed, to pressure stability, record data such as pressure P1, the liquid,

c. use the prepared liquid to 0. microbial 3mL/min speed to pressure stability, records data such as pressure P2, solution,

d. JQ simulating water with 0.3mL/min speed drive to pressure stability, records data such as pressure P3, a volume,

e. changes in the permeability of the model 100, 500, 1000mD, experiment and record parameters such as pressure, fluid, judge strain Ns4, Ns8 and WP1 in the different permeability under injection.

3.2. Experimental results and analysis

(1) Study on permeation rate of 100, 500, 1000mD conditions, permeability on strain effect of injection pressure in the Ns4 model JQ, study its ability to inject.

Table 1 Ns4 injection in the varying permeability model JQ table

Number the cores	permeate , mD	ΔP,MPa	Inject Ns4ΔP2,MPa	ΔP3,MPa
ZRJQ1-1	90.12	0.011	0.018	0.015
ZRJQ2-1	456.34	0.003	0.005	0.004
ZRJQ3-1	968.75	0.001	0.003	0.002

The table 1 shows that, as the volume increases, the pressure is increased slightly and levelled, Ns4 strains with different permeability cores are not blocked, and the injection pressure is not high, smooth infusion; stable pressure P3 is slightly higher than that of the subsequent water flooding water measured pressure P1.

(2) Study on permeation rate of 100, 500, 1000mD conditions, Ns8 JQ permeability on strain effect of injection pressure in the model to study the injection.

Table 2 Injection ability table of Ns8 bacteria in different permeability JQ models

Number the cores	permeate , mD	ΔP,MPa	Inject Ns8ΔP2,MPa	ΔP3,MPa
ZRJQ1-2	96.32	0.012	0.019	0.014
ZRJQ2-2	426.87	0.002	0.006	0.004
ZRJQ3-2	1021.35	0.001	0.004	0.002

The table 2 shows that, as the volume increases, while slightly increasing pressure and levelled; Ns8 strains with different permeability cores are not blocked, and the injection pressure is not high, smooth infusion; stable pressure P3 is slightly higher than that of the subsequent water flooding water measured pressure P1. As Ns8 Ns4 and degradation of surfactant producing bacteria viscidity, so the injection pressure is not high, and smooth injection.

(3) Study on permeation rate of 100, 500, 1000mD conditions, permeability on strain WP1 JQ effects of injection pressure in the model, study its ability to inject.

Table 3 Injection capacity of Wp1 in the varying permeability model JQ

Number the cores	permeate ,mD	ΔP,MPa	Inject Wp1ΔP2,MPa	ΔP3,MPa
ZRJQ1-3	89.26	0.013	0.685	0.436
ZRJQ2-3	512.34	0.002	0.341	0.232
ZRJQ3-3	989.65	0.001	0.159	0.089

The table 3 shows that, as the WP1 volume increases, the pressure is increased injection pressure P2 in strain was far higher than the water pressure P1, the pressure of succeeding water flooding down from stable pressure P2 P3 injected strains, polymer-producing strain WP1 cores to improve the effect of mobility ratio. Comparative table 1~3, respectively, in the same permeability, water, temperature and other conditions, strain WP1 highest injection pressure and strain of Ns4 and Ns8 injection pressure than water flooding with a slight increase.

4. Study on the effect of microbial injection for combination flooding

4.1. Experimental steps

a. constant temperature box temperature 35 ℃, core models exhaust air for 4h, JQ saturated block of simulated water, place 8h;

b. Water permeability cores saturated oil, oil saturation calculation and place 8h;

c. use JQ block simulating water with 0.1mL/min water flooding experiment of speed, to core export water 98%, recording parameters such as pressure, fluid, calculate the water flooding recovery;

d. using a prepared mix liquid to 0.1mL/min microbial tests of speed, slug size 0.1PV, place 48h;

e. use JQ block simulating water with 0.1mL/min speed of displacement, to core export water to 98%, recorded data such as pressure, fluid, calculate the rate of microbial enhanced oil recovery;

f. the microbial slugs the size of change (0.1, 0.3, 0.5 and 0.7PV), microbiological and subsequent water flooding experiment and record parameters such as pressure, liquid output, calculation of mixed fluid in microbial enhanced oil recovery rate under different slugs [7].

4.2. Experimental results and analysis

Water flooding water 98%, research concentrations are 3% of mixed bacteria is 0.1, 0.3, 0.5, 0.7PV JQ flooding effect in the model, given its reasonable amount.

Table 4 Bacterial oil displacement effect table of different infusions

Number the cores	Permeate , mD	Experimental scheme	water drive recovery factor	injection rate of injection and subsequent water flooding
JQ5-5	489.23	Water flooding +0.1PV mixed strain + 48 hours + subsequent water flooding	29.58%	2.25%
JQ5-1	495.34	Water flooding +0.3PV mixed strain + 48 hours + subsequent water flooding	30.58%	5.29%
JQ5-2	501.69	Water flooding +0.5PV hybrid strain + 48 hours + subsequent water flooding	30.88%	5.78%
JQ5-6	492.76	Water flooding +0.7PV hybrid strain + 48 hours + subsequent water flooding	30.35%	6.03%

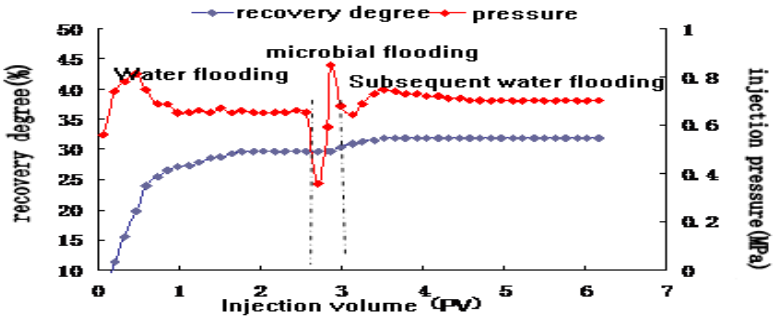

Figure 4 JQ5-5 0.1PV hybrid strain recovery and pressure curve

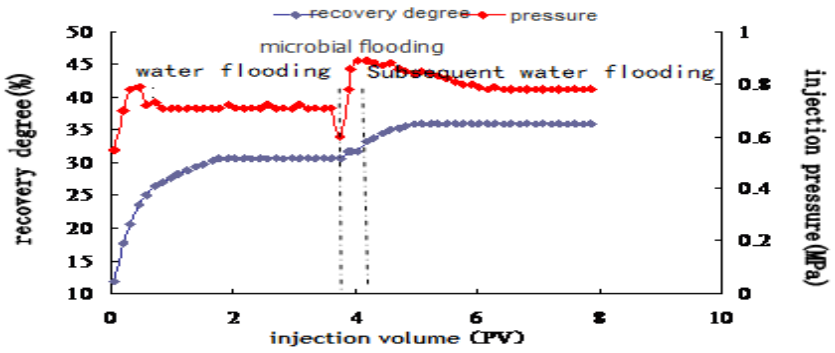

Figure 5 JQ5-1 0.3PV hybrid strain recovery and pressure curve

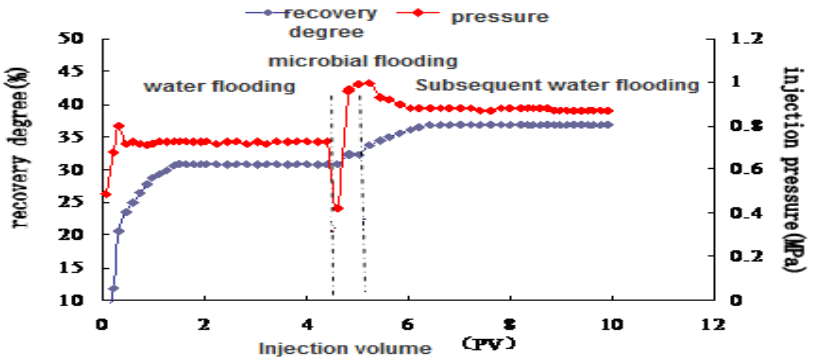

Figure 6 JQ5-2 0.5PV hybrid strain recovery and pressure curve

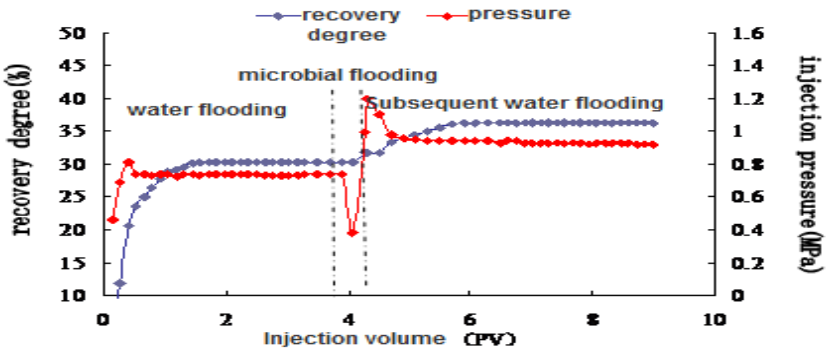

Figure 7 JQ5-6 0.7PV hybrid strain recovery and pressure curve

Figure 4 to7 shows that the water pressure displacement increased rapidly with water after flooding, oil continued outflow of core, low water pressure displacement and become stable. After injecting bacteria increasing pressure, elevated pressure of succeeding water flooding, after stabilizing. With the increase of injecting, injection-bacteria + follow-up water drive recovery efficiency also increased, while mixed strains of injection pressure and subsequent water flooding pressures have increased. Water rate curves can be seen, supply of mixed bacteria reduced water content. Hybrid solution combines the advantages of three bacteria, which can broaden the swept volume, and improve the efficiency of oil, as well as degradation of heavy oil and mining.

5. Conclusion

Ns4, Ns8, Wp1 strains were adapted to model JQ and cultured strains in the model Ns4, Ns8, Wp1 short adaptation period of stable for long periods. Ns4, Ns8, Wp1 strains in the core showed great vitality.

Injection pressure is higher than bacteria strain mixture of water flooding before the pressure of water flooding. As the volume increases the follow-up water drive pressures are becoming more stable, good compatibility with the formation of mixed bacteria, clogging does not occur, you can meet the requirements field test of injection.

Injection of 0.1, 0.3, 0.5, 0.7PV Eor after mixed strains are 2.25%, 5.29%, 5.78%, 6.03%. As the volume increases recovery rate increased significantly, increases are getting smaller, when volume of more than one range, even if increased volume and recovery rates also increase very little or no increase. Consideration of the input-output ratio, quantity is 0.3PV is more reasonable.

Acknowledgments
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