Scholars Journal of Engineering and Technology (SJET)
Sch. J. Eng. Tech., 2014; 2(3C):463-466
ISSN 2321-435X (Online)
ISSN 2347-9523 (Print)

Research Article

The Research of Ultra-low Permeable Reservoir Horizontal Well Pattern Optimization

Yang zhao*, Gao han, Bai mingxing
Petroleum Engineering Institute, Northeast Petroleum University, Daqing Heilongjiang 163318, China

***Corresponding author**
Yang zhao
Email: gaohan2008-2008@163.com

Abstract: Horizontal well fracturing technology is a low permeable oilfield development mining technology. Reservoir physical properties changes after fracturing. In this paper, on the basis of a large number of indoor experiments, we analyze the threshold pressure gradient, pressure sensitive effect after fracturing. In view of the actual block, in the process of numerical simulation, considering the above change rule, and adopts the method of orthogonal experiment, optimization was studied for the low permeability reservoir horizontal well pattern.
Keywords: Ultra-low Permeable ; Threshold Pressure Gradient; Stress Sensitivity; Orthogonal Test

INTRODUCTION

1985 Giger [1] first proposed the concept of horizontal well fracturing, and now it has become one of the horizontal well fracturing improved ultra-low permeability reservoir horizontal well production and effective manner. But in the fracturing process, reservoir properties will change. Results of Lu Cheng Yuan [2] and Fatt [3], who studies show that starting pressure gradient and stress sensitivity change significantly before and after fracturing. In the existing simulation software [4-7], but also not fully considers these effects. In this paper, based on a large number of laboratory experiments, studied before and after fracturing pressure gradient and pressure sensitivity variation. Considering the above factors, the actual numerical simulation study commenced black block 168, using the method of orthogonal experiment, for ultra-low permeability reservoir horizontal well pattern optimization.

Variation of reservoir properties after fracturing study

The oil phase starting pressure variation

Experiment of after fracturing starting pressure changes: According to the scene to provide the core data, used in the production of indoor simulation core. Take permeability were 0.1mD, 0.3 mD, 0.5mD, 0.7mD, 1mD, 5mD core level, studying the variation of after fracturing oil phase starting pressure.

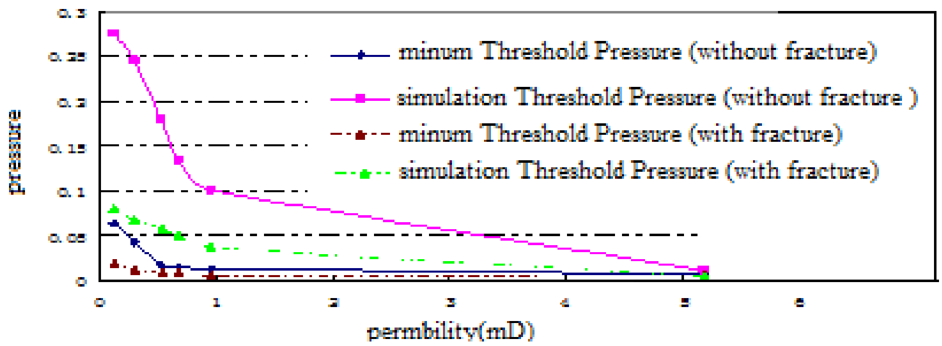

Fig-1: Starting pressure gradient under different permeability

As can be seen from Figure 1: The minimum starting pressure gradient and the proposed core pressure gradient of the core after fracturing has decreased significantly, when the core has cracks, its threshold pressure has reduced to 1/3 compared with the dense core which has the same permeability.

$$y = 0.0538x^{-0.7006} \qquad (R^2 = 0.9173) \qquad (1)$$

The formula: x is the permeability of the core; y is the starting pressure of Corresponding penetration.

Changes in pressure sensitivity

Changes in pressure sensitivity experiments: According to the scene to provide the core data, used in the production of indoor simulation core. Taking permeability were 0.1mD, 0.3 mD, 0.5mD, 0.7mD, 1mD, 5mD core level, studying stress sensitivity variation after fracturing.

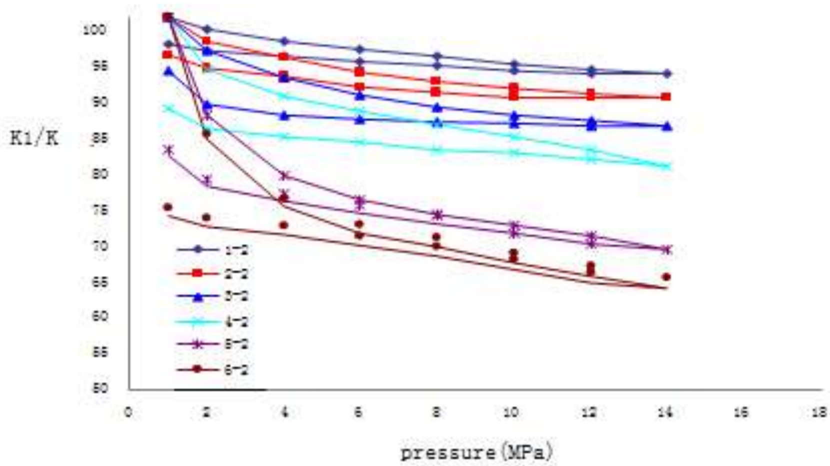

Fig-2: Dimensionless permeability changes under different permeability

The results showed that: Compared with the previous fracturing, the Dimensionless permeability is reducing when the effective pressure is increasing. Ultra-low permeability reservoir original pressure is higher, the greater the magnitude of the dimensionless permeability reduction after fracturing. Based on the experimental results, the regression of pressure sensitivity variation with pressure:

$$y = -8.2552\ln(x) + 82.145 \quad (R^2 = 0.5743) \quad (2)$$

The formula: x is the permeability of the core; y is the s Dimensionless permeability

Orthogonal experimental designs

The basic theory of orthogonal design

Orthogonal experimental design is an important method on the study of multi-level and multi-factor design, It is based on the orthogonal of selected some representative from comprehensive test points for the overall design, comprehensive comparison and statistical analysis, These typical points with the "evenly dispersed, neat than" characteristics. It by means of the orthogonal table, from among all the possible match some necessary test, the test for typical data as less as possible, and then use statistical analysis method for integrated processing of the experimental results, analysis of the optimal solution.

Determine the orthogonal design table

In the case of selected five point method systems, the orthogonal design method to optimize horizontal well pattern parameters. According orthogonal design optimization requirements, the entire optimization is divided into three factors, each divided into five levels.

Three factors: horizontal wellbore length, well spacing, row spacing, five levels of each factor:

horizontal wellbore length: ①300m②500m③700m④900m⑤1000m

well spacing: ①200m②250m③300m④350m⑤450m

row spacing ①150m②200m③300m④350m⑤400m

Using reservoir numerical simulation method to optimize well pattern parameters design. Adopted by the numerical simulation model and the form of well pattern optimization model used in exactly the same. To screen out the five point well pattern (WP1) as the target well pattern, horizontal well length and row spacing in order to optimize the target parameter, single well early production capacity (1 year) and the recovery degree of 10 years as the optimization goal. Same failure of bottom-hole flowing pressure 6.8 MPa, respectively 20 MPa on bottom hole flowing pressure and pressure water injection Wells, considering the horizontal wellbore internal friction losses. Simulation to predict time for 10 years, comparing various performance index of the pattern test, optimization of horizontal well pattern parameters.

The five point well pattern optimization results

According to the well pattern parameter optimization orthogonal design table (table 1).On the basis of the actual model on black 168 with a five-spot method well pattern (different horizontal wellbore length , well spacing, row spacing) to well spacing again , and process numerical simulation for 10 years. The simulation results of the production of technical indicators as follows:

Table 1: Well pattern parameter optimization orthogonal design table

factor	horizontal wellbore length（m）	well spacing（m）	row spacing（m）	factor	horizontal wellbore length（m）	well spacing（m）	row spacing（m）
text1	300	200	300	text14	700	350	400
text2	300	250	400	text15	700	400	450
text3	300	300	450	text16	800	200	400
text4	300	350	150	text17	800	250	450
text5	300	400	200	text18	800	300	150
text6	500	200	200	text19	800	350	200
text7	500	250	300	text20	800	400	300
text8	500	300	400	text21	1000	200	450
text9	500	350	450	text22	1000	250	150
text10	500	400	150	text23	1000	300	200
text11	700	200	150	text24	1000	350	300
text12	700	250	200	text25	1000	400	400
text13	700	300	300				

Table-2: The five-spot well pattern parameters optimizing production index simulation results

Program	Length - spacing - row spacing	Initial single well productivity（m^3/d）	Single well oil production the end of the decade（m^3）	recovery degree（%）	The average oil production speed（%/年）	Water cut（%）	Formation pressure（MPa）
1	300-200-300	8.36	4364	8.39	0.84	82.84	10.98
2	300-250-400	8.67	4305	4.73	0.47	54.84	13.42
3	300-300-450	7.87	4120	4.53	0.45	46.55	13.69
4	300-350-150	6.39	2995	10.86	1.09	94.81	10.44
5	300-400-200	5.82	3527	9.30	0.93	88.80	10.70
6	500-200-200	13.08	6261	11.01	1.10	91.40	10.63
7	500-250-300	12.88	7235	9.54	0.95	81.15	11.90
8	500-300-400	10.35	6173	5.43	0.54	52.39	13.99
9	500-350-450	10.09	6093	5.36	0.54	43.46	14.68
10	500-400-150	12.94	5043	12.19	1.22	92.42	12.35
11	700-200-150	17.72	9863	9.75	0.98	89.27	11.69
12	700-250-200	12.85	10722	13.66	1.37	82.72	12.13
13	700-300-300	12.37	11994	14.50	1.45	74.12	12.80
14	700-350-400	17.26	2869	5.20	0.52	47.26	12.97
15	700-400-450	17.88	3777	4.98	0.50	37.08	13.19
16	800-200-400	18.77	8811	5.81	0.58	57.12	13.43
17	800-250-450	16.42	8206	5.41	0.54	48.31	13.76
18	800-300-150	20.90	6236	7.54	0.75	94.81	8.81
19	800-350-200	20.74	7774	6.83	0.68	88.91	9.31
20	800-400-300	19.01	7893	5.20	0.52	79.36	10.42
21	1000-200-450	13.88	7166	3.15	0.31	47.79	12.23
22	1000-250-150	23.37	7069	8.54	0.85	95.35	8.72
23	1000-300-200	24.61	8298	7.29	0.73	89.60	8.71
24	1000-350-300	24.70	8082	5.33	0.53	82.59	10.97
25	1000-400-400	16.74	6892	5.33	0.53	47.66	12.24

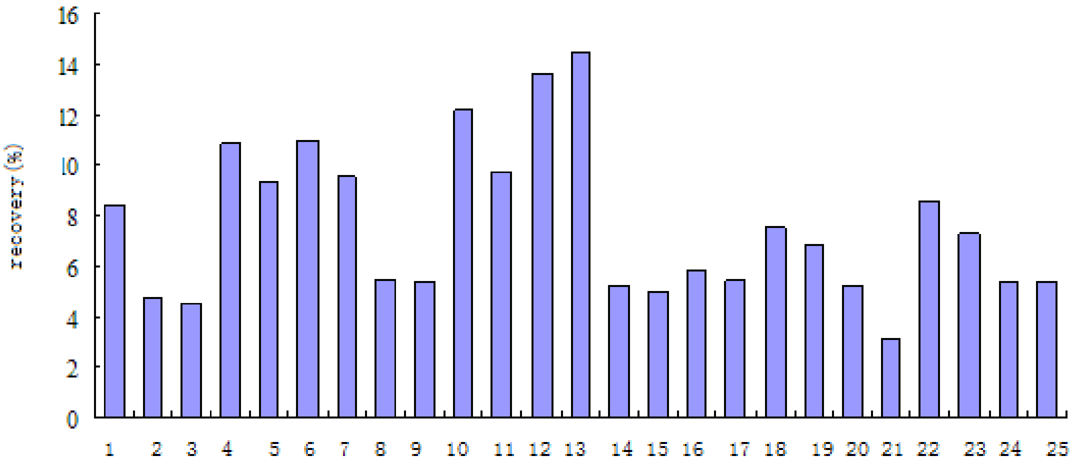

Fig-3:The histogram of recovery degree under different solutions (five spot well pattern)

Compared to Production targets of 25 Orthogonal design under five spot well pattern , From the end of the decade of the programs histogram view of the extent of recovery, That program 13, horizontal section length of 700 m, row spacing distance is 300 m, has the best development effect, The end of the decade recovery degree was 14.5%, the average recovery rate is 1.45.

CONCLUSION

1. when the core has cracks, its threshold pressure has reduced to 1/3 compared with the dense core which has the same permeability. According to the results, we can get the starting pressure variation with permeability: $y = 0.0538x^{-0.7006}$ .The presence of cracks, pressure sensitivity also changed, according to the experimental results, the variation of pressure sensitivity analysis before and after fracturing as: $y = 0.0538x^{-0.7006}$ 。
2. Orthogonal test method is a highly efficient, fast, economical method of experimental design, It use orthogonal table as a tool to pick out a number of necessary tests from all possible match and obtain typical data with little experiment. In this paper, optimizing the choice of three factors, five levels, to determine the 25 groups of test solution.
3. By orthogonal experiment, numerical simulation results show that: Under the five-point method WP1 wells pattern, That program 13, horizontal section length of 700 m, row spacing distance is 300 m, has the best development effect, The end of the decade recovery degree was 14.5%, the average recovery rate is 1.45.

Acknowledgements

This work is supported by the National Natural Science Foundation of China (Grant No. 51304049), the Scientific Foundation for Returned Scholars of Heilongjiang Province in China (Grant No. LC2011C28), and the Scientific Foundation for Young Teachers of Northeast Petroleum University in China (Grant No. ky120238). Furthermore the authors would like to thank all members of the research team.

REFERENCES

1. Zhang Juntao, Shen Feng, Wu Jinqiao , Tao Hongsheng; Horizontal well fracturing technology in the application of the low permeability reservoir. Journal of Yangtze university (JCR Science Edition) sciences, 2012; 7(7):65-67.
2. Lv Chengyuan, Wang Jian, Sun Zhigang; Experimental study of the starting pressure gradient in low permeability sandstone reservoir. Petroleum Exploration and Development, 2002; 29(2): 86.
3. Giger F M. Horizontal wells production techniques in heterogeneous reservoirs. SPE 13710, 1985.
4. Yang Zhengming,Yu Rongze, Su Zhixin; A low permeability reservoir of nonlinear seepage numerical simulation [J]. Petroleum Exploration and Development, 2010; 37(1):94-98.
5. Yang Renfeng, Jiang Ruizhong, Liu Shihua, Zhang Xiaoliang, Liu Haicheng; A low permeability reservoir of nonlinear seepage numerical simulation . Acta Petrolei Sinica, 2011;3(2):299-306.
6. Hao Fei, Cheng Linsong, Li Chunlan; Considering start-up pressure gradient of low permeability reservoirs unstable seepage model． Oil Drilling & Production Technology，2006; 28(5)58-60．
7. Han Hongbao, Cheng Linsong, Zhang Minglu; Special consideration of start-up pressure gradient of low permeability reservoirs, the physical simulation and numerical simulation method．Journal Of Petroleum University，2004;6(28)：49-53．