Air flooding numerical simulation research of Shen 150 block

Yuxi Zhao [1, a], Tongtong Yu [2, b], and Haiyu Yang [3, c]

[1]College of Petroleum Engineering, Northeast Petroleum University, Heilongjiang 163000, China

[2]The First Oil Extraction Plant of Daqing Oilfield Company Limited, Heilongjiang 163000, China

[3]Daqing Oil Field Co, Heilongjiang 163000, China

[a]1170553127@qq.com, [b]zyxjingjing@163.com,[c]286788704@qq.com

Abstract

After nearly 20 years of large-scale water flooding development, the oilfield of Shen 150 block has entered into high water cut stage. The research optimization optimum displacement solution on the basis of geological modeling and water flooding history fitting. The solution reduce the risk of field test and provide reference for air injection flooding of low permeability oil reservoirs. The result of simulation show that Shen 150 block has certain feasibility to air injection displacement that can draw partly difficultly recoverable reserves effective, improve development effect.

Keywords

Air injection；indoor experiment；numerical simulation；scheme optimization；Shen150 block.

1. Introduction

The block Shen 150 is a low-permeability oil reservoir whose geological stocks were supposed to be 1015.6×10^4t, owing inferior recovery rates,characterized by heavy heterogeneity vertically and tiny thickness[1]. It's not until 2012 that there attained cumulative oil output of 77.5×10^4 t and relevant recovery rate as 6.79%. The difficulty in waterflooding emerged in the middle and late exploration period has brought about the matter that a portion of oil-water wells failed to operate properly. The recovery rates dropped evidently due to deficiency of timely supplements of formation energy[2].

Considerable researches have revealed that air injection exerted efficaciously on facilitating exploiting low permeability reservoirs, enabled to settle the inability to establish effective pressure systems in waterflooding extraction of low-permeability reservoirs[3-4]. Several abroad reservoirs have ever succeeded in putting gas injection into exploration, whose effects remarkably superior to that in waterblooding extraction[5]. Certain domestic reservoirs have also carried out field experiments which attained preliminary effects[6]. Air injection was idealized in exploiting for relying on lower cost and never restricted by air supply[7].

2. Feasibility prediction of air injection displacement.

Strict feasibility analysis shall be passed previously to reaching a consensus on the item decision of air injection displacement, whereas screening methods and parameter standards failed to be quantified for impacted by some factors like oil prices and investments[8]. The block Shen 150 has been running under the temperature around 96℃, in the depth of 2700-3100m, taking up the oil saturation of 60% and the viscosity of crude oil lower than 10mPa s in the oil reservoir. The crude oil performed well in oxidation dynamics, enforceable in the secondary recovery of low-permeability light oil reservoirs that had proved unfit for waterflooding, and the third recovery of oil reservoirs whose residuals had turned over-saturated after waterblooding. The studied block confirmed to applicable conditions of air injection displacement[9].

3. Screening for well groups.

The predictable schema of air injection displacement shall screen out reasonable well groups for prediction, principally taking account of the well pattern and the injection-production relation of Block Shen 150. The screening principles of gas-injection wells were listed as followed:

(1) The gas-injection layer shall lie in high position and high level possibly, which ensures to process oil displacement by supplying formation energy from the pressure in gas caps.

(2) The injection-production well spacing shall be kept in slender distance owing to that untimely breakthrough would generate gas channeling, which has the potential to spring into the oil well and trigger accidents.

(3) Guarantee high saturation of surplus oil and favorable connectivity among injection-production wells.

4. The comparison among developing modes

Compared the production effects possessed by different stimulated displacing media of waterflooding mode and air injection displacement, setting the predictable period as 2 years. The developing responses in different developing modes have been showed as followed:

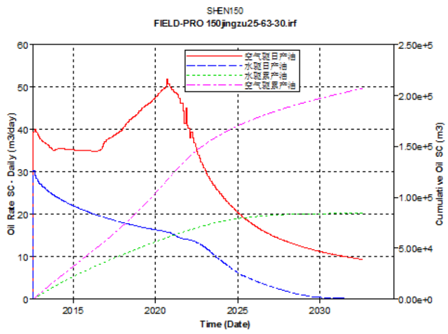

Figure 1 Curves of Oil Outputs under Different Developing Modes

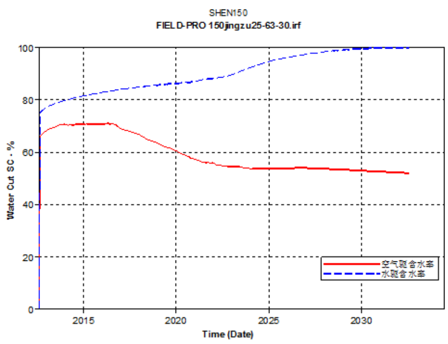

Figure 2 Varying Curves of Water Contents under Different Developing Modes

The dynamic curves(Figure 1 , Figure 2) representing production effects under different developing modes revealed that, daily oil outputs under air injection displacement were significantly higher than those under waterflooding mode, meanwhile, water contents of the reservoir dropped down apparently once injecting air, the rates of producing oil and the recovery rates as injecting air have improved over one tine than those as injecting water. Considering severe heterogeneity in the reservoir of Block 150 , the flooded water would flow through the wide channel, which might lead to inefficient water injection and ensuing poor developing results; The air displacement has succeeded in establishing the pressure displacement system, combined with temperature effects and the action of CO_2, which actually has attained superior development effects.

5. Optimizing parameters of air injection

5.1 Optimization of gas volume

As oxygen in injected air reacted with the crude oil gradually, inevitably emerged oxygen among producing gas in the later stage would interrupt safe production in oil reservoirs, therefore checking for oxygen content frequently in the later stage shall be put on the agenda, for convenience of pondering on further transformation modes in case of oxygen produced. To Block Shen 150, the recovery performs best as setting the gas volume as 10000m^3/d.

Table 1 Comparison of Production Effects among Different Gas Volumes

Gas volume（m^3/d）	Production time (a)	Initial daily oil outputs of single well (t/d)	Average daily oil outputs of single well（t/d）	Cumulative oil outputs（10^{4}t）	Water content (%)	Recovery rates（%）	Oxygen discovering time (a)
1000	20	8.32	4.38	12.79	49.65	1.26	/
5000	20	8.21	5.42	15.82	51.35	1.56	/
10000	20	8.12	5.82	17.00	52.05	1.67	/
15000	20	8.04	5.06	17.72	54.12	1.74	16.0
20000	20	7.97	6.24	18.22	55.93	1.79	10.8
25000	20	7.88	6.37	18.61	57.74	1.83	8.4
30000	20	7.79	6.48	18.94	59.85	1.86	8.0

5.2 Optimization of the water-gas alternating period.

Maintaining the gas-liquid ratio (500:1) and aggregated injection volume consistent, set respectively the stimulated periods as 30 days, 60 days, 90 days, 120 days and 180 days, subsequently made a prediction of recovery effects under different water-gas alternating periods. The stimulated results indicated that daily oil outputs varied under different water-gas alternating periods, while cumulative oil outputs and the variation trend of water contents remained consistent. Therefore, the duration of periods indeed exerts slightly on stimulated effects. Besides, the shorten periods facilitated in enlarging the diffusion degrees aimed to both phases of water and gas, and enhancing displacing results, while relatively shorter periods brought about cumbersome requirements to field operations, which counted against oil arrangement. Accordingly ponder over generally as selecting alternating periods to avoid extremely frequent periods. The most rational period shall be approved as 30 days.

5.3 Optimization of gas-liquid ratio as water alternating with gas.

Carried on the stimulated recovery via models respectively under gas-liquid ratios as 50:1, 100:1, 200:1; 500:1 and 1000:1, then predicted recovery effects under different gas-liquid ratios.

Considering poor physical property of formations in Block Shen 150, unsatisfied waterflooding effects, and high initial waterflooding pressure, the water volume shall be kept from too large. It suggested to inject mass air for supplying the formation pressure. Owing to the lower initial pressure of air injection and the oxidation reaction between air and the crude oil in the formations, the growing temperature of formations would reduce viscosity of the crude oil and induce chemical flooding, eventually the gas volume far exceeds the water volume. However, extremely high ratio of gas to liquid might lead to that the features of displacement inclines to gas drive and the cost increases. Taking indexes like oil outputs and water contents into account generally, the optimal gas-liquid ratio in Block Shen 150 shall be designed as 500:1.

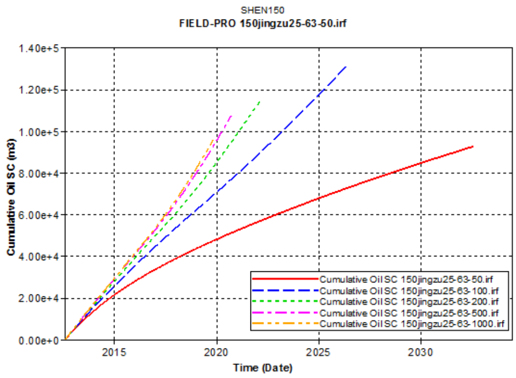

Figure 3 Comparison of Cumulative Oil Outputs under Different Gas/Liquid Ratio of Block Shen 150

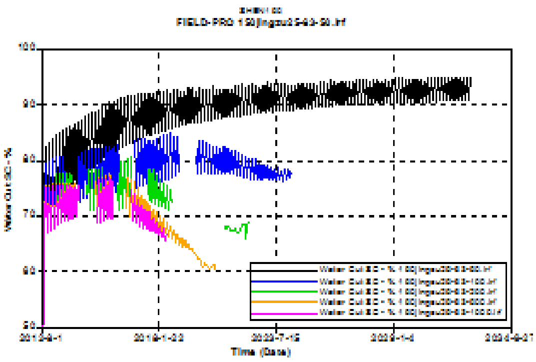

Figure 4 Comparison of Water Contents under Different Gas/Liquid Ratio of Block Shen 150

6. Prediction of gas injection schema in Block Shen 150.

According to optimized results of well groups in Bloch Shen 150, ascertained the optimal parameters for gas injection in Block 150: the water-gas alternating period as 30 days, the gas-liquid ratio as 500:1, daily gas volume of single well as 10000m^3/d, on the bedrock of which, established stimulated operation for 5-year indexes, ultimately obtained various production indexes as followed:

Table2 Predictions of Various Indexes

Production time	Daily oil outputs	Annual oil outputs	Water content	Recovery rates
1st year	107	35552	74.85	0.35
2rd year	111	40768	72.02	0.40
3nd year	113	41243	71.83	0.41
4th year	115	41969	71.16	0.41
5th year	116	42271	70.93	0.42

7. Conclusions

(1) According to given results measured in indoor experiments and research results of numerical stimulation research findings, drew up principles for selecting well groups, then provided references for future numerical stimulation research of air injection displacement in reservoirs; put forward alternative optimization of parameters of air injection displacement in the block, proposed 5-year output predictions for the block on the basis of optimized results, that the recovery rate would achieve excepted results.

(2) Investigating successful gas-injection cases at home and abroad, we have agreed on criteria for screening reservoirs, illustrated the feasibility of air injection displacement in the block combined

with actual reservoir features in Block Shen 150. As to ultra-low permeability reservoirs, the economic benefits of air injection displacement remarkably overweighs that of waterflooding model. Air injection technology shall be reckoned as a strategic technical reserve to supply technical supports for boosting ultimate recovery rates of ultra-low permeability reservoirs.

Reference

[1]Li Yanting, Lin Meili , DU Xin, Ju Weilon. The development index research of Bei 301 block[J]. Petrochemical Industry Application, 2010, 01:39-41.

[2]Jiang Youwei, Zhang Yitang, Liu Shangqi, Guan Wenlong, Chen Yaping, Liu Shuangmao. Displacement mechanisms of air injection in low permeability reservoirs[J]. Petroleum Exploration and Development, 2010, 04:471-476.

[3]Gu Yonghua ,He Shunli ,Tian Ling, Lv Zhikai .Air injection to improve recovery efficiency numerical simulation research[J]. Journal of Chongqing University of Science and Technology (Natural Sciences Edition), 2010,05:82-84+87.

[4] FASSIHI M R , GILLHAM T H . The use of air injection to improve the double displacement process[C]//SPE Annual Technical Conference and Exhibition , 3-6 October1993, Houston , Texas.

[5] FASSMI M R, YNNIMARAS D V , KUMAR V K. Estimation of recovery factor in light-oil air injection projects[J].SPE Reservoir Engineering , 1997 , 12(3) : 173-178.

[6] GREAVES M, REN S R, XIA T X.New air injection technology for IOR operations in light and heavy oil reservoirs [C] / / SPE Asia Pacific Improved Oil Recovery Conference , 25-26 October 1999 , Kuala Lumpur , Malaysia.

[7]Wang Yanqiu, Song Kaoping, Sun Jiansong .Research and Understanding of Oil Displacement by Air Injection in Extra-low Permeability Oil Fields[J]. Sino-Global Energy,2012,04:59-63.

[8]Wang Zhiyong. Study of Improved Oil Recovery through Air FoamFlooding [D].China University of Petroleum,2009.

[9]Yu Lianjun, Wu Xinrong, Guan Jianqing, Zhang Qingsheng. The optimization of gas lift distribution technology and economic evaluation [J].Journal of Jianghan Petroleum Institute, 2003, 02:87 -88+10.