# Research on reasonable injection-production ratio of water flooding in the high water cut stage of Lamadian oil field

Xiaoshuang Dong

No.6 Production Plant Of Daqing Oil Field

**Keywords:** water flooding, injection-production ratio, layer pressure, material balance method

**Abstract:** Lamadian oilfield has developed since the year 1973, which has passed a number of large-scale adjustment. It has come multiple sets of layers and sets of well pattern development pattern, injection-production relationship is complex and ineffective circulation. Therefore, It is necessary to study the reasonable injection-production ratio of water flooding in ultra high water cut stage. Under the premise of ensuring the layer energy, increase the utilization rate of water injection. In this paper, the material balance method is selected according to the actual development characteristics of oil field, The relationship between the liquid yield, water injection quantity and formation pressure is studied, to make clear the scale of reasonable production, calculation and reasonable prediction of injection production ratio, to provide the basis for the planning and regulation of water flooding in oil field.

## Introduction

Since the water flooding in Lamadian Oilfield has been put into production in 1973, it has experienced a number of large-scale developments and adjustments, and formed a series of development patterns with multiple sets of layers and multiple wells. But with the transition zone third infilling production, comprehensive water cut increase and two flooding of oilfield injection transfer, expanding, interlayer and plane contradiction, invalid injection increasing, injection production ratio has changed greatly. Therefore, it is necessary to carry out the reasonable injection production ratio, adjust the injection production structure, and control the ineffective water injection on the premise of ensuring the sufficient formation energy, so as to adapt to the further development of Lamadian oilfield.

## Determination of reasonable injection production ratio

**Injection production relationship survey.** From overall view of water flooding, before "12th Five-Year" the injection production ratio is above 1.30, the formation pressure rising steadily, increasing production pressure difference, in the time that the production rate is fast, the higher the injection production ratio to ensure the formation energy is sufficient. After "12th Five-Year", the water flooding oil production rate slowed down, the formation pressure and production pressure difference remained relatively stable, the injection production ratio gradually decreased to about 1.23, to meet the needs of oilfield development. The wells actual injection production ratio is different from the sets. Basic well pattern and injection production ratio between 0.82 to 0.98, primary infilling injection production ratio between 1.66 and 1.38, secondary infilling injection production ratio from 2.89 to 1.60, due to water flooding layers adjustment and re-perforation messed up development layers. Different sets of well pattern crossed together to make injection production relationship complex. It can not reflect the actual injection ratio of each set of well

Copyright © 2017, the Authors. Published by Atlantis Press.
This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

pattern in multilayers injection system. Therefore, the author intends to calculate reasonable injection production ratio directly from the entire water flooding system.

**Theoretical derivation.** Water flooding sandstone reservoir injection production ratio is an important index of oil production and injection proration. Injection production ratio reasonable or not directly affects the level of formation pressure and oil reservoir production capacity. In determining the reasonable injection production ratio is often lack of a simple and effective method, usually determined by virtue of experience, not conducive to improve the overall management the level of reservoir. The author uses the material balance equation starting from the injection balance principle, using the method of theoretical derivation and actual data fitting, through the rational formation pressure drop to determine the reasonable injection production ratio.

$$IPR = 1 - \frac{K_2}{Q_L}\Delta P \tag{1}$$

In formula: $K_2$ ——Water invasion coefficient, $\times 10^4 m^3/(a\cdot MPa)$;

$Q_L$ --- Annual output， $\times 10^4 m^3$

Part of the invalid injection inevitably showed with the exploitation prolonging and more oil wells, the ground and underground increasingly complex. It refers to oilfield development history, oilfield management level and the main adjustment methods. It generally increases along with the development of oilfield, but decreases with the improvement of management. However, in a specific stage of development, the proportion of invalid water injection is close to a fixed value.

$$(1-S)\times IPR = 1 - K_2\frac{\Delta P}{Q_1} \tag{2}$$

$$IPR = \frac{1}{1-S} - \frac{K_2}{1-S}\times\frac{\Delta P}{Q_1} \tag{3}$$

$$\frac{1}{1-S} = a\ ,\quad \frac{K_2}{1-S} = b$$

$$IPR = a - b\times\frac{\Delta P}{Q_L} \tag{4}$$

**Determination of reasonable injection production ratio.** According to the above formula results, combined with the water flooding well network from 2001 to 2015, with an annual output of actual water injection fluid volume, water content, formation pressure and actual production data, the actual oil Delta P/QL value and injection production ratio linear relationship IPR.

$$IPR = 1.3221 + 331.44\times\frac{\Delta P}{Q_L}$$

According to the above linear formula, the ratio of S to water flooding in Lamadian oilfield is 24.36%, and the effective injection production ratio of water flooding in 2015 is about 1.01, and the annual invalid water injection rate was up to $1474.4\times 10^4 m^3$. But considering the actual situation of our factory water flooding wells on subsequent water flooding block, alone on water flooding was calculated and can not reflect the invalid injection ratio and effective injection production ratio, therefore, the water flooding and subsequent water flooding as a whole to be calculated, obtained actual △P/QL value and the linear relationship of IPR.

$$IPR = 1.083 - 337.75\times\frac{\Delta P}{Q_L}$$

According to the fitting results, the proportion of invalid injection S is 7.66% in water flooding and subsequent water flooding. To maintain the formation pressure and liquid production scale in 2015, there needs more than 1.13 to the actual injection production ratio, 1.04 of effective injection production ratio and the invalid injection up to $747.8\times10^4m^3$.

**Application example.** In 2015, Northwest block of water flooding and subsequent water flooding,which injected water with an annual injection of 1035 * 104m3, producing an annual output of $825\times10^4$t liquid containing $31\times10^4$t oil, having an injection production ratio of 1.24, total pressure -0.87MPa and comprehensive water content as high as 96.25%. The invalid injection cycle here is serious. Therefore, fitting the actual production data from 2001 to 2015, the actual block △P /QL value and injection production ratio of IPR linear relationship are calculated. We concluded that maintaining annual production scale and pressure level in 2015 and reasonable injection production ratio of 1.08, the annual invalid water injection is up to $115.5\times10^4m^3$.

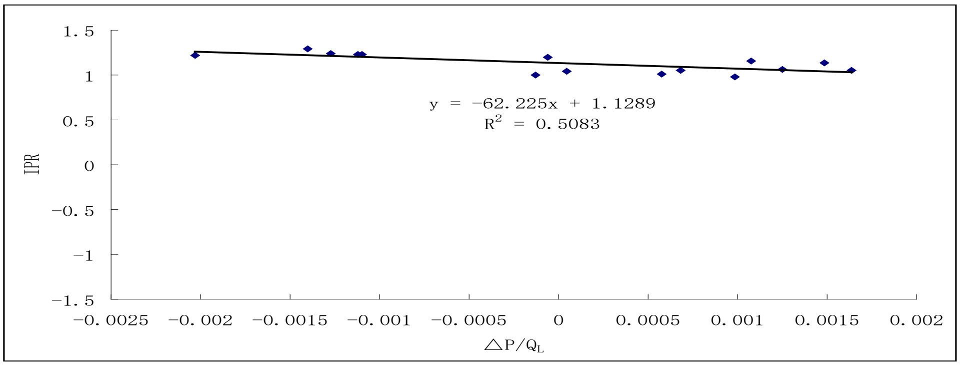


Fig. 1 The IPR linear relationship of Northwest block of water flooding and subsequent water flooding

According to the above research results, combined with the needs of the production situation, The water flooding integrate schemes in 2014 and 2015, increase water control adjustment to high injection production ratio, high pressure and high water-cut zone, decreasing ineffective injection. Comparing to 2013,the Northwest block improved in many aspects, such as injection water lower by $61.5\times10^4m^3$ and $112.4\times10^4m^3$ in 2014 and 2015, water flooding injection production ratio reduced from 1.24 in 2013 to 1.14, the water flooding natural decline rate controlling to 3.62%, annual water decreasing by 0.10 and 0.16 percentage, the formation pressure relatively stable, maintaining a high level of development, the actual development results coinciding with the calculated results.

## "13th Five-Year" reasonable injection production ratio prediction

Firstly using a regular curve and the water flooding curve, we predict the next five years reasonable liquid production scale and production rate. Secondly according to the fitting formula, we can forecast reasonable injection production ratio for water flooding and subsequent water flooding. In a word, we expect the actual injection production ratio about 1.13, effective injection production ratio 1.04 and the annual scale of invalid injection around $640\times10^4m^3$, in Lamadian oilfield water flooding and subsequent water flooding during "13th Five-Year" period.

Table 1 Lamadian oilfield water flooding "13th Five-Year" during the reasonable injection production ratio prediction table

| Time (year) | Forecast Liquid yield ($10^4$t) | Actual Injection production ratio | effective Injection production ratio | invalid Water flooding ($10^4m^3$) |
|---|---|---|---|---|
| 2016 | 5355 | 1.13 | 1.04 | 646 |
| 2017 | 5437 | 1.13 | 1.04 | 644 |
| 2018 | 5388 | 1.13 | 1.04 | 643 |
| 2019 | 5401 | 1.13 | 1.04 | 642 |
| 2020 | 5461 | 1.13 | 1.04 | 640 |

## Conclusion

(1)The actual injection production ratio is about 1.20, mainly due to the invalid water injection and subsequent water flooding;

(2)By means of regression analysis of actual production, total pressure drop and injection production ratio, the ratio of invalid water injection can be calculated quantitatively;

(3)during the period of "13th Five-Year", Lamadian oilfield water flooding and subsequent water flooding actual injection production ratio is 1.13, compared to effective injection production ratio at 1.04, with an invalid injection scale of 640×104m3.

## Reference

[1] Xu Jianjun, Xu Yan-chao, Yan, Li-me,et.al. Research on the method of optimal PMU placement. International Journal of Online Engineering,v9, S7, p24-29, 2013

[2] Xu Jian-Jun，Y. Y. Zi.，Numerical Modeling for Enhancement of Oil Recovery via Direct Current. International Journal of Applied Mathematics and Statistics，2013，43（13）：318-326

[3] Longchao, Zhu Jianjun, Xu; Limei, Yan. Research on congestion elimination method of circuit overload and transmission congestion in the internet of things. Multimedia Tools and Applications, p 1-20, June 27, 2016

[4] Yan Limei, Zhu Yusong, Xu Jianjun,et.al. Transmission Lines Modeling Method Based on Fractional Order Calculus Theory. TRANSACTIONS OF CHINA ELECTROTECHNICAL SOCIETY, 2014 ,Vol.29,No. 9:260-268 (In Chinese)

[5] YAN Li-mei, CUI Jia, XU Jian-jun,et.al. Power system state estimation of quadrature Kalman filter based on PMU/SCADA measurements. Electric Machines and Control. 2014, Vol.18 No.6,: 78-84. (In Chinese)

[6] YAN Limei,XIE Yibing, XU Jianjun, et.al. Improved Forward and Backward Substitution in Calculation of Power Distribution Network with Distributed Generation. JOURNAL OF XI’AN JIAOTONG UNIVERSITY,2013, Vol.47, No.6, p117-123. (In Chinese)

[7] Xu J.J., Gai D., Yan L.M. A NEW FAULT IDENTIFICATION AND DIAGNOSIS ON PUMP VALVES OF MEDICAL RECIPROCATING PUMPS. Basic & Clinical Pharmacology & Toxicology, 2016,118 (Suppl. 1), 38-38