# The layered water injection research of thin oil zones of Xing Shu Gang oil field

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**Abstract.** As the continuous development of oil fields, the mode of oil field water injection changed from the early general water injection into layered water injection, subdividing series of strata gradually stratified water flooding of water injection until now. After subdividing water injection measures, as an intuitive depicting its single well water injection measures segment before and after the contrast of injection profile, introduces the concept of Lorenz curve in the segmentation evaluation before and after water injection. The living cells-recognition lens the degree of curvature of curve and the use of Lorentz curve has calculated the Gini coefficient can be clearly more subdivided the uniformity of injection profile before and after water injection. At the same time using the cumulative injection profile producing extent, bibulous ply calculated from the profile degree of uniformity, use two ways to evaluate the injection profile. Because of the influence of the longitudinal heterogeneity reservoir, its reservoir features are different. Statistical evaluation data, in combination with the practical situation of reservoir geological analysis of the reservoir itself subdivided injection line, using fine hierarchical way to dig up the potential of reservoir water flooding, improve the development effect.

# Introduction

In the process of the development of Xing Shu Gang oil field using way to increase production of oil field water injection. Early in the oilfield development, the contradiction between interval layer is small, each small layer water absorbing capacity, so we use the general way of water injection[1-2].With the continuously development oilfield, the disadvantages of water injection is also increasingly appeared[3]. With the increasing understand of reservoir geological structure deepening by people, zonal injection began to gradually replace the general water injection [4-5]. Gradually with the development of Xing Shu Gang oil field into high water-cut stage, development target transformed from high permeable zone transferred to low permeable formation, gradually transferred from thick reservoir to thin and poor reservoir, the original separation degree is no guarantee that the residual oil layer water injection technique, for the reservoir of thin, Xing Shu Gang oil field in small layers of fine hierarchical measures were taken to the reservoir[6-7].After the precise layering measures, the poor thin layers in Xing Shu Gang oil field improve the output of certain.

With the precise layering measures of the poor thin layers in Xing Shu Gang oil field, analyse the single well injection profile data which before and after the measures.

# The analysis of poor thin layer of the Xing Shu Gang test well layered water injection effect

Evaluation is the target reservoir water flooding effect is the most intuitionistic data, use of statistical tests before the layered water injection well producing extent data, make the test Wells producing extent bar chart according to the statistics of the data, as shown in figure 1.



Figure 1 layered water injection test well before using bar charts

From the table, we can see that the test well after general water injection reservoir to improve the degree of use of certain, but most of the test well producing extent is still less than 50%, so it is necessary for zonal injection. Work for can more accurately describe the layered water injection using situation of reservoir, after introducing the Lorentz curve, uniformity contrast before and after water injection profile, combined with the profile degree of uniformity, reservoir using two aspects of comprehensive analysis.

## Lorenz curve evaluation the thin layer water absorption profile uniformity

Lorenz curve reference to research on the layered water injection profile, according to the principle of Lorentz curve [8-9], the thickness of a single well sort by water quantity from high to low, then consider bibulous the best to the worst of any percentage thickness corresponding to the water absorbing capacity of percentage. Will like to get the thickness of the cumulative percentage and water quantity cumulative percentage corresponding relation graph, which is described injection profile of Lorenz curve and Gini coefficient calculation. The definition of the Gini coefficient is refers to the actual Lorenz curve and the area of the "absolute uniform line" surrounded by A of "absolute uniform line" and "absolute uneven line" between the proportion of area B, because the formation coefficient of Lorenz curve can be formed by complex graphics simplified into multiple similar trapezoidal section area of the sum of. Each percentage of formation coefficient and the first n accumulation and ordinal number percentage, Yn on behalf of the first n percentage accumulation and formation coefficient, as shown in figure2.



Figure 2 injection profile Lorentz curve

The Gini coefficient calculation formula is:

$$G = \frac{\sum_{n=1}^{n} (X_n - X_{n-1}) (Y_n + Y_{n-1})}{10000} - 1$$

## The analysis of poor thin layer of layered water injection effect

After the measures for the layered water injection test pressure Wells, the Gini coefficient and use of the results in column form, and select the typical Wells in mapping analysis.

| Test well number | Gini coefficient |       | Degree of development/% |       |
|------------------|------------------|-------|-------------------------|-------|
|                  | before           | after | before                  | after |
| 1                | 0.830            | 0.687 | 28.44                   | 41.78 |
| 2                | 0.572            | 0.495 | 55.37                   | 53.06 |
| 3                | 0.727            | 0.534 | 36.36                   | 61.81 |
| 4                | 0.813            | 0.782 | 18.78                   | 24.44 |
| 5                | 0.638            | 0.779 | 47.42                   | 24.39 |
| 6                | 0.724            | 0.379 | 42.37                   | 77.86 |
| 7                | 0.442            | 0.268 | 55.86                   | 68.02 |
| 8                | 0.912            | 0.784 | 12.44                   | 42.91 |
| 9                | 0.448            | 0.849 | 74.27                   | 20.39 |
| 10               | 0.578            | 0.667 | 50.44                   | 53.77 |
| 11               | 0.583            | 0.364 | 43.31                   | 79.75 |

Table 2 blocks within the single well data statistics

From table 2 we find most of the test data comparison before and after the layered water injection well in the same trend, namely the Gini coefficient is reduced, water absorption profile use degree increased. Select a well as an example mapping analysis.

To test no.1 well as an example, the layered water injection before and after the Lorenz curve drawing and use the degree of contrast figure 3, figure 4.



Figure 3 layered water injection before and after the adjustment the Lorenz curve



Figure 4 layered water injection adjustment before and after use

Compared with the data table, the well Lorentz curve more intuitive description of the layered water injection before and after injection profile of uniformity. By the table, you can see that the thickness of the 30% to reach 100% of the water quantity, the Gini coefficient is 0.83, and after this value increased by more than 40%, the Gini coefficient decreased to 0.687. Zonal injection after the Lorenz curve is closer to the absolute uniform line, which means that the poor thin layer after layer water injection. Through the above analysis, most test Wells in the layered water injection measures after the same change trend, namely the layered water injection, reservoir producing extent with the change is closely relative to the uniformity of injection profile. So in the process of oilfield water injection development, to improve the poor thin layer of the uniform degree of injection profile, on the basis of the layered water injection technology, the poor to the thin Xing Shu Gang oil field study on stratified water flooding reservoir.

#### Poor thin layers of stratified water flooding research

We can see through the study of fine geology that control the internal development of poor thin layer structure in poor thin layer when determining remaining oil, the main factors including lithological interface and physical interface. These two kinds of interface in the plane distribution under the premise of stability, both in the vertical direction of fluid seepage has certain barrier, it widen the train of thought for further subdivided injection research.

#### Poor thin layer of fine layered boundary research

In order to improve reservoir producing extent, reduce the invalid water injection in high water cut blocks, fine on the blocks in Xing Shu Gang oil field was carried out layered water injection line of research, study the various factors influencing the degree of use of the reservoir. The results show that the single card number of reservoir, these two parameters on the condition of using sandstone thickness effect is more noticeable. Standard reasonably come to the subdivided injection block parameters were analyzed, and quantitative parameters within the interval, in elaboration standard, can be popularized to other oil block.

Within a niche water injection interval, using degree as the single card small layer and increase with the decrease of the thickness of sandstone, and so, in theory, the subdivision reservoir use it the better. But because of the limitation of water injection process to block of data statistics, through the analysis it is concluded that a reasonable single card number of reservoir and sandstone thickness values. Respectively using linear regression method to make a single card number, sandstone thickness of reservoir and the use of the degree of fitting relationship, as shown.

| Number of reservoir | Degree of development/% |  |
|---------------------|-------------------------|--|
| 2                   | 0.894                   |  |
| 3                   | 0.773                   |  |
| 4                   | 0.493                   |  |
| 5                   | 1.057                   |  |
| 6                   | 0.845                   |  |
| 7                   | 0.500                   |  |
| 8                   | 0.539                   |  |
| 9                   | 0.362                   |  |
| 11                  | 0.347                   |  |
| 12                  | 0.334                   |  |
| 13                  | 0.609                   |  |
| 14                  | 0.514                   |  |
| 15                  | 0.497                   |  |
| 16                  | 0.091                   |  |
| 17                  | 0.581                   |  |

Table 3 single degree of reservoir with the use of statistics

By fitting the diagram analysis, single card number of reservoir and the degree of the reservoir with several relations in pairs, the correlation coefficient is 0.66, interval and the number of single card reservoir within reservoir producing extent relationship is more noticeable. Single card reservoir in the interval number less than 8, the number of single reservoir effective bibulous rate can reach more than 50%.



Figure 5 single card number of reservoir and the degree of the use of fitting diagram

| Sandstone thickness | Degree of development/% |  |
|---------------------|-------------------------|--|
| 3.5                 | 0.811                   |  |
| 4.5                 | 0.523                   |  |
| 5.5                 | 0.581                   |  |
| 6.5                 | 0.506                   |  |
| 7.5                 | 0.408                   |  |
| 8.5                 | 0.601                   |  |
| 9.5                 | 0.444                   |  |
| 10.5                | 0.824                   |  |
| 11.5                | 0.377                   |  |
| 12.5                | 0.355                   |  |
| 13.5                | 0.482                   |  |
| 14.5                | 0.418                   |  |
| 15.5                | 0.038                   |  |
| 16.5                | 0.239                   |  |
| 17.5                | 0.352                   |  |
| 18.5                | 0.195                   |  |
| 19.5                | 0.391                   |  |

Table 4 sandstone thickness and the degree of the use of statistics





By fitting the diagram analysis, single card sandstone thickness and degree of reservoir with several relations in pairs, the correlation coefficient is 0.75, good correlation. Period of single card sandstone thickness is less than 11 meters, single reservoir effective bibulous rate can reach more than 50%.

#### Poor thin layers stratified water flooding adjustment

In order to further improve the quality of water injection, improve poor thin layer development effect, on the basis of water injection line segment, to optimize the combination of each interval, the specific method is:

(1) Aimed at the poor thin layers in injection Wells, using the packer seal high suction unit, strengthening of water injection in low permeability layer. If there are two types of reservoir intervals between layers is small, can't use packer for each card open water injection. If only rely on profile control to adjust the injection profile, will not only increase the cost, and short validity, the effect is not obvious. So using long rubber tube sealing properties in this paper, a new method, namely the sacrifice and nearby a poor thin layer, high aquifer will stop invalid single card production layer out note, other poor reservoir water flooding.

(2) based on several large difference of suction in the injection Wells, invalid water injection is frequently poor thin layers, take more period of high water absorption in the sealing layer, layer for the corresponding interval block in the way.

Valid for a single after the layered water injection producing extent is still less than 50% of the injection well separated from segmentation as the key object, should be paid attention to in the hierarchical difference between layers is controlled properly, in order to ensure balance of each layer water injection. Mainly choose the secondary and the tertiary infilling poor thin layers as

object segmentation, the development potential of the well is bigger, can be adjusted to segment the injection Wells, improve the excavating potential of remaining oil.

# Conclusion

Stratified water flooding reservoir after the injection profile is more uniform, the use of degree is higher, therefore in the process of oilfield water injection development, to improve the poor thin layer of the uniform degree of injection profile, on the basis of the layered water injection technology, to the poor thin Xing Shu Gang oil field study on stratified water flooding reservoir.

By the method of linear regression analysis shows that single card number of reservoir and the degree of the reservoir with several relations in pairs, the correlation coefficient is 0.66, when the reservoir interval single card less than 8, the number of single sandstone effective bibulous rate can reach more than 50%. Single card sandstone thickness and degree of reservoir with several relations in pairs, the correlation coefficient is 0.75, correlation is better. Interval single card sandstone thickness limit of 11 m, less than this value, the single water absorption ratio can reach more than 50%. Injection Wells by using water injection line segment method of each interval is optimized restructuring, to develop the potentiality of adjustment, of tertiary infilling of the major goals, to improve the residual oil potential.

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