Potential Tapping of Low-yield Wells in Southern X Area of Sanan Development Zone

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Abstract: After water flooding in Sanan Oilfield enters the ultra-high water cut stage, the distribution of remaining oil is highly scattered, and it is more and more difficult to control water cut rise and production decline. To this end, the special opening oil layer has a small perforation thickness, high water cut, imperfect injection and production relationship, and low degree of multi-directional connectivity control in the southern X zone test area, through the fine hole filling measures to rebuild and tap different types of remaining oil to improve mining. Out of degree.

1. Basic Survey of South X Area

1.1 Geological survey

1.1.1 Geographical location and structural features

Nan X area is located in the south of Saertu oilfield in Daqing placanticline. There are six normal faults in the block. The fault horizon ranges from Mingshui Formation to Gao IV Formation with a maximum fault distance of 59.5m. The top burial depth of Sa I reservoir is 751-1047 m, and the oil-water interface depth is 1088-1197 M.

1.1.2 Reservoir physical characteristics

The Sa, the Portuguese and the high oil layers in the South X area are a set of gray, gray-green sandstone interbedded sediments, which are the second and third sections of the Qingshankou Formation in the Mesozoic Cretaceous. The Sa, Mg and Gao oil layers in the South X area belong to the large river-delta sedimentary system in the Songliao Basin. They are deposited in the inner and outer fronts of the delta, and calcareous bands are developed in the sand layer. Ostracoda fossils are found in the Sa, Portugal and high oil reservoirs in Nan X area, which are sandwiched with muddy strips. Horizontal bedding is dominant and oil-bearing occurrences are diverse. Thick oil reservoirs are mainly oil-rich and oil-bearing, while thin oil reservoirs and surface reservoirs are mostly oil-immersion and oil spots.

1.1.3 Sedimentary characteristics of oil reservoirs

Sa, Portugal and high oil reservoirs are developed in Nan X area, which belong to the inner and outer front facies of delta. The average thickness of sandstone drilled by a single well is 140.09m and the effective thickness is 56.79m.

1.2 Development survey

In 1965, 520m-540m four-point method was adopted to develop the area-based well pattern in Nan X area. The well pattern density was 5.54 wells/km2. In 1988, an infilling adjustment was made for the poor Sa+Portugal II reservoirs except Sa II 7-12 reservoirs. The four-point pattern of water injection wells in the middle point of the original well pattern was used for production, with a well spacing of 260-270m and a well pattern density of 21.85 wells/km2. In 1998, the second encryption adjustment was carried out. The adjustment target was the Sa+Port II group of thin oil reservoirs and off-balance-sheet reservoirs. The wells were arranged at the midpoint of the triangle formed by the basic well network and a single encrypted oil well to form a linear water injection.

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1.3 Problem

1.3.1 The oil layer is not used evenly, and the proportion of the oil layer is low.

The results of 93 water injection profiles since 2012 show that the utilization ratio of sandstones in reservoirs with effective thickness (> 1 m) is 73.83%, that of sandstones in reservoirs with effective thickness (> 1 m) is 58.56%, that of sandstones in reservoirs with effective thickness (> 1.0 m) is 40.91%, and that of sandstones in reservoirs with effective thickness (> 0.2-0.4 m) is only 33.09%.

1.3.2 High proportion of ultra-high water cut wells in block

At present, there are 197 wells in the production wells in the block, and the proportion of wells with water content greater than 94% is as high as 37.1%, and the proportion of extra-high water wells with water content greater than 95% accounts for 23.9%.

The production well has a long ratio of low production and low production wells, and the injection and production are relatively high.

At present, the total number of wells in the production wells is 224, and the number of wells is 197. The rate of well opening is 87.9%, including 22 Changguan wells, 30 low-yield wells, 23.2% of long-closed low-yield wells, and 1.33 annual injection-production ratios.

Among them, the secondary encryption adjusts the lowest proportion of low-yield wells in the well network, and the thin oil layer and the off-balance reservoir in the Sa+Port II group are mined. The remaining oil distribution is highly scattered. The water content of some production wells continues to rise, and the daily oil production of single wells gradually decreases. The development contradiction is the most serious. 118 wells were opened in December 2015 with secondary infilling adjustment well pattern. The average daily liquid production of single well is 31t, the daily oil production is 2.3t, the comprehensive water cut is 92.59%, and the submergence degree is 207m. 33.05% of wells with daily oil production less than 1 T and 55.93% of wells with water cut higher than 93%.

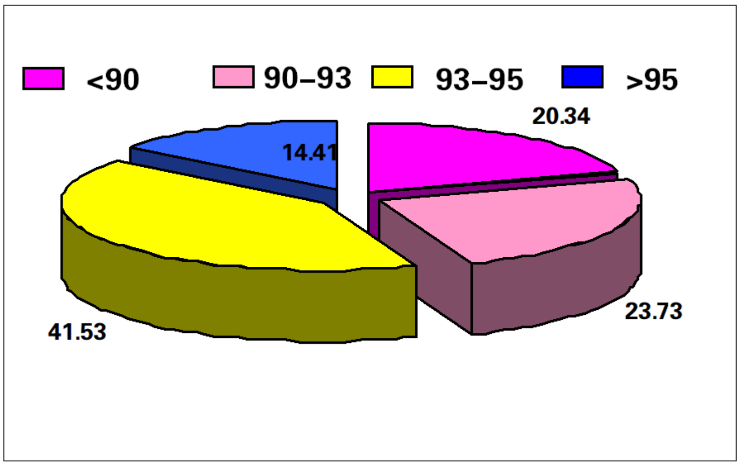


Fig.1. Water cut classification scale chart of well pattern

Table 1 Production classification Table of well pattern

Yield classification (t)	Well number (mouth)	Proportion (%)	Daily liquid production in single well (t)	Daily oil production of single well (t)	Comprehensive water content (%)
≤0.5	10	8.47	6.8	0.5	94.12
0.5-1.0	29	24.58	13.2	0.9	94.06
≥1.0	79	66.95	37.5	3.3	92.45
Total	118		31.0	2.3	92.59

The average perforated sandstone thickness and effective thickness of single well are 18.4m and 2.7m for secondary infilling adjustment well pattern production wells. By December 2015, cumulative oil production is 197.14 x 104t, and the average recovery degree of single well pattern is 62%. Of these, 54 wells are larger than the average level of well pattern. 48.31% of the wells with effective thickness less than 2 m were perforated.

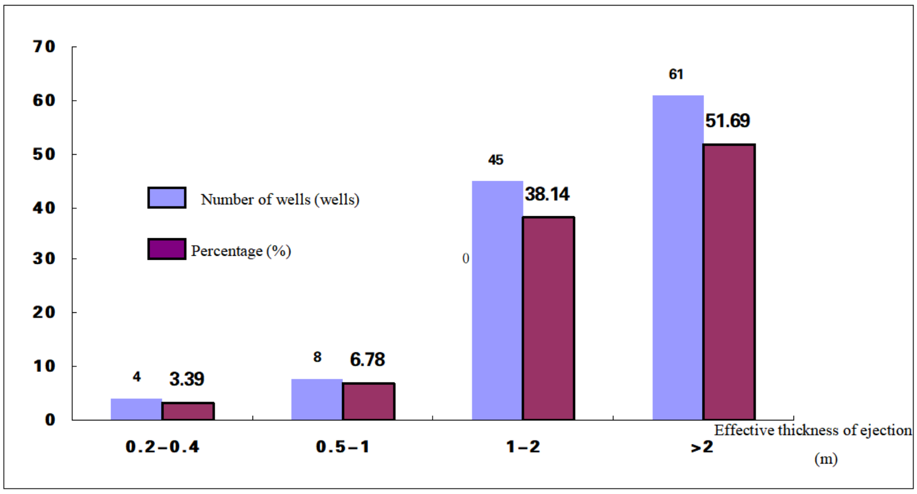


Fig.2. Schematic diagram of effective thickness well proportions by staged perforation

The reservoirs in the southern X block are characterized by many oil layers, thin thickness and strong heterogeneity. The secondary encryption adjustment well network is deeply affected by the buried depth and the injection-production well spacing, and the utilization condition is poor. The data of the three consecutive water absorption profiles of the whole well network were counted. The sandstone utilization ratio was 14.3%, and the effective utilization ratio was 23.9%.

Table 2 Well network utilization status

Effective level (m)	Statistical well number	Perforation condition			Continuous water absorption 3 times			Continuous water absorption 3 times		
		Layer number (a)	Sandstone (m)	Effective (m)	Layer number (a)	Sandstone (m)	Effective (m)	Layer number (a)	Sandstone (m)	Effective (m)
(1,2]	25 mouth	9	14	11.3	4	6.7	5.2	44.44	47.86	46.02
(0.4,1]		80	81.6	52.8	18	19.8	13	22.5	24.26	24.62
(0,0.4]		149	134.5	44.4	26	27.2	7.8	17.45	20.22	17.57
Off-balance sheet		470	334.3		38	27		8.09	8.08	
Total		708	564.4	108.5	86	80.7		12.15	14.3	23.96

2. Optimum Selection Method and Effect of Complementary Well Layer

2.1 Maintain the integrity of the well pattern

In order to maintain the integrity of the well pattern and ensure the independence of different well patterns, the injection-production relationship of single sand body is improved on the basis of not disturbing the perforated objects, and the hole filling is carried out only for the production wells of this well pattern. Finally, 7 oil wells were recharged.

2.2 The replenishment object is mainly composed of thin oil layer and off-surface reservoir. The remaining oil is dominated by poor water absorption and large injection-production well spacing.

Seven wells were counted, and the oil layers of Sa II7-Sa II12 and Portuguese I were deducted. The average single well drilled sandstone with a thickness of 57.4 m and an effective thickness of 20.1 m.

Table 3 Diameter of drill hole thickness

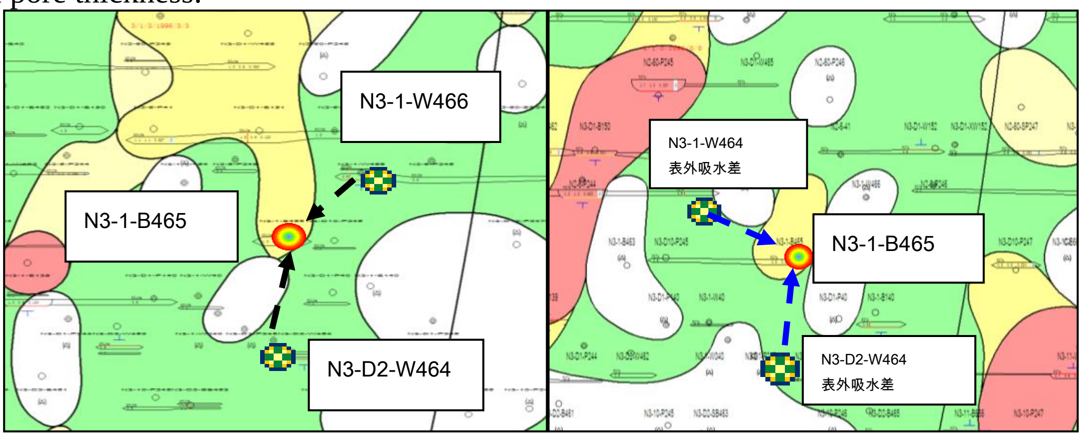
Oil layer	Effective thickness ≥0.5m oil layer		Effective thickness 0.2-0.4m oil layer		Off-balance sheet (m)	Total	
	Sandstone (m)	Valid (m)	Sandstone (m)	Valid (m)		Sandstone (m)	Valid (m)
Sa Group I	5.4	3.2	3.7	2	9.4	18.5	5.2
Sa II7-12	63.3	54.9	14.2	6.5	8.6	86.1	61.4
Sa II group other	46.8	37.2	24.6	8.9	21.1	92.5	46.1
Sa Group III	37	28	19.5	8.4	30.4	86.9	36.4
Portuguese group I	116.1	91.7	26.3	8.6	16.7	159.1	100.3
Portuguese II	29.6	23.4	30	9	38.7	98.3	32.4
High I group	16.9	11.7	21.5	7.9	60.5	98.9	19.6
High group II	2.4	1.2			4.4	6.8	1.2

Through layer-by-layer analysis of non-perforated horizons, deducting the watered-out horizons on the mainstream line and those around which there is no water injection wells to replenish, the main replenishment horizons are residual oil with poor water absorption and uncontrollable injection-production well spacing. For the injection and production imperfect, due to the plane phase change frequently formed the residual oil reservoir hole filling potential. For the one-time encryption injection well, the residual oil can not be controlled, and the filling and filling relationship is improved to improve the degree of water flood control.

Table 4 Residual oil type classification Table

Types of remaining oil	0.2-0.4m		0.5-1.0m		>1.0m		Total	
	Sandstone	Valid	Sandstone	Valid	Sandstone	Valid	Sandstone	Valid
Poor water absorption in wells	10.7	3.4	7.8	5	4	3.6	22.5	12.0
Lump sand body	4.7	1.9	1.7	2.1	6.3	4.4	12.7	8.4
A well pattern can not be controlled	3.4	1.2	10.7	5.5			14.1	6.7
Variable position	4.2	1.4	4.2	2.8	1.4	1.2	9.8	5.4
Imperfect injection-production at fault edge	0.8	0.4			2.6	2	3.4	2.4
Decompression (with or without injection)	2.4	0.5	3.2	1.4			5.6	1.9
Total	26.2	8.8	27.6	16.8	14.3	11.2	68.1	36.8

Among them, residual oil with poor water absorption and Tuffy sand body account for 55.43% of the total pore thickness.



(a) (b)

Fig.3. Schematic diagram of residual oil with water absorption difference

Secondly, the large spacing of primary infill injection and production wells and the existence of slow injection wells in some wells lead to uncontrollable residual oil formed by sand bodies in some secondary infill production wells, accounting for 18.21%.

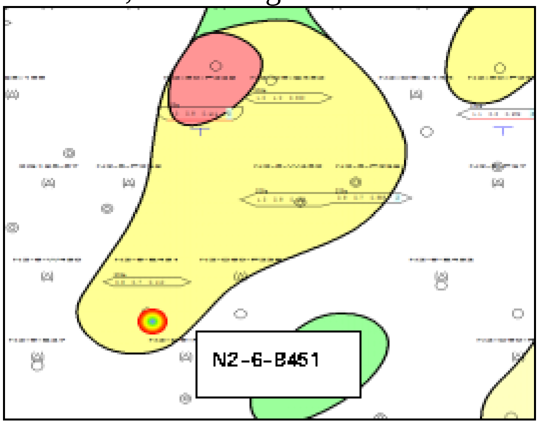


Fig.4. Schematic diagram of tucked sand body

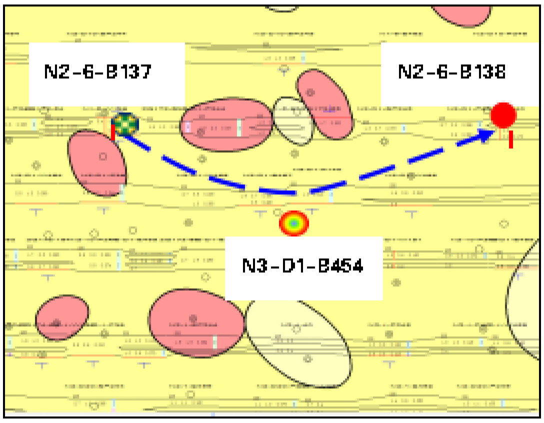


Fig.5. A schematic diagram of uncontrollable well pattern

2.3 For low-efficiency production wells with less effective thickness of remaining oil in the whole well, the water cut limit of remaining oil can be appropriately relaxed and some oil-water layers can be recharged.

A total of 94 sub-layers were identified, with an average thickness of 14.8m and an effective thickness of 5.3m. Most of the targets for hole-filling are thin and poor reservoirs. Among them, 39.36% are outer layers and 34.33% are thickness. The ratio of the effective layer thickness of 0.2-0.4 m oil layer is 29.79%, and the proportion of sandstone and effective thickness accounts for 25.27% and 23.91%, respectively. The proportion of layers with an effective thickness of 0.5-1.0 m was 24.47%, and the proportion of sandstone and effective thickness accounted for 26.62% and 41.46%, respectively. The proportion of the oil layer with an effective thickness of 1.0 m or more was 6.38%, and the proportion of sandstone and effective thickness accounted for 13.79% and 29.62%, respectively.

Table 5 Filling hole thickness classification Table

Small number of holes	Replenish sandstone	Make up effective	Off-balance sheet		0.2m≤Effective≤0.4m			0.5≤Effective＜1.0m			1.0m≤Effective		
			Small number of layers	Sandstone	Small number of layers	Sandstone	Effective	Small number of layers	Sandstone	Effective	Small number of layers	Sandstone	Effective
94	103.7	36.8	43	38.8	28	26.2	8.8	23	27.6	17.1	6	14.3	10.9
Proportion /%			39.36	34.33	29.79	25.27	23.91	24.47	26.62	41.46	6.38	13.79	29.62

3. Hole filling effect

Pre-selected wells have been repaired successively. The average daily increase of oil per well is 2 T after repairing, and the cumulative increase of oil is 0.18 x 104t in the same year, which slows down the natural decline rate of the second infilling adjustment well pattern by 2.2 percentage points in the same year, thus effectively tapping the remaining oil potential.

At the same time, the scheme adjustment and injection stimulation measures should be carried out to ensure the effect of hole filling.

Table 6 Water injection well adjustment and measures

Mode	Number of wells (wells)	Before adjustment			After adjustment		
		Segment(s)	Daily annotation (m^3)	Daily Notes (m^3)	Segment(s)	Daily annotation (m^3)	Daily Notes (m^3)
To subdivide	1	5	80	76	6	90	90
Self tuning	2	9	135	136	9	170	176
acidification	3	13	210	105	13	210	203
fracture	1	5	95	39	5	105	105

4. Conclusion

After the oilfield development enters the ultra-high water cut stage, the distribution of remaining oil is more scattered. Only by continuously refining the genetic analysis and deepening the reservoir understanding, can the recovery degree be further improved.

The remaining oil potential of low-yield wells in Nan X area is thin and poor reservoir and off-surface reservoir, which ensures the independence of different well patterns, does not disturb perforation targets and maintains the integrity of each well pattern.3, After the completion of the hole filling, timely tracking and adjustment of the injection wells in the well area and measures to increase the effect of the hole filling effect.

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