

PRELIMINARY ANALYSIS ON THE APPLICATION OF COMMUNICATED BRINE EXTRACTION WELLS IN MULTI-BEDDED AND THINLY-BEDDED SALT DEPOSIT

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Abstract: This paper mainly introduces the application of naturally-communicated well pair and directional drilling communicated well pair in Jiangxi Salt Mine Co., Ltd. And it also analyses the character of each in exploiting the multi-bedded and thinly-bedded salt deposit, and it holds that the directional drilling communicated well pair is the best choice of exploitation process.

Key word: Natural communication; Directional drilling; Application; Understanding

PREFACE

Jiangxi salt mine Limited liability company locates at Zhangshu Jiangxi Province where is also called as "the capital of Chinese medicine". The mining area is monoclinical structure that belongs to the north part of the Qingjiang salt mine, the trend of structural configuration is NE60° and favors SE. The attitude of stratum is smooth, inclination angle general is 3-5° and the crevasse does not grow. The ore section is mainly the rock salt mine and rich in glauberite. It is stored in the third part of Qingjiang(Eq1) stratum with slightly wrinkling structure. Three groups of crevasses full filled with orange can be observed obviously.

The ore deposit shows zonation, salt-bearing series in Qingjiang group is built by chips, it performs, from bottom to top, as a set of thick - thin - thick and the color is red -

ash - red, according to the different deposition environment. The salts mineral present the combination of anhydrite glauberite anhydrite - rock salt glauberite glauberite anhydrite - anhydrite from the bottom to the top, and down sulfate belt, chloride belt and up sulfate belt are divided clearly. The salt bed has 54 layers at most, the accumulative thickness of mining area salt bed is 112 meters, the single-layer general is 1.5-4.0 meters, the number 22 salt bed in main ore bed amount to 10.8 meters and the bottom plate of salt bed roof mainly is laminated mudstone and salty nature mudstone. Jiangxi salt mine limited liability company has two sets of co-production of salt and Glauber salt's installment with 300,000 ton annual output, and the total annual output amounts to more than 850,000 tons. At present the expanding of high-purity salty technological transformation project with 100,000 tons product is undergoes. At that appointed time, the annual

output will achieve to more than 1,000,000 tons. The working area has 24 production brine wells, among them there are 5 single well convection brine wells and 14 directional drilling communicated wells, the directional drilling communicated well is the main production brine well in this mining area.

THE CHARACTERS OF COMMUNICATED BRINE WELL

The communicated brine well realizes the connection through natural solution and communication, hydraulic fracturing and directional drilling. Comparing with the single well convective well, it has some advantages include big flow rate, high density, long servicing time, low accident rate, high recovery ratio, steady production, simply operation and so on.

NATURAL SOLUTION AND COMMUNICATIVE SALINE WELL

In the production process of single well convection, the sum of single well and single well salt cavern radius achieves or surpasses the length of well spacing, then causes single well salt caverns connected with each other. This is called natural solution and communicative saline well

Our company has numbers of brine well which is natural solution and communication. They are 21-22-28, 23-29-30, 32-33, 4-5-6-7 and so on. Because of the single well convective production, so the accident rate is high and the salt bed roof is extremely easy to collapse, which cause the draft-tube wrap, distortion and shear break, additionally the production layers upper shift. Therefore natural solution and communicative saline well general mine the upper salt bed. According to the geological feature of ore deposit, its upper part is rich with glauberite which is soluble mineral. While brine extraction and rock salt dissolution, the glauberite is also dissolved. The dissolved characteristic of glauberite mineral is: it decomposes to sodium sulfate and calcium sulfate after meeting with water, but most of the calcium sulfate crystallizes to gypsum immediately and sediment in the cavity. Sodium sulfate dissolves in the brine, makes sodium sulfate in the original halogen of natural solution and communicative saline well stay at a high level. Analysis on part of original halogen quality in saline well is shown in Table 1. Therefore the natural solution and communicative saline well does not have a big significance in Qingjiang salt ore deposit.

Table 1. The analysis on brine quality in natural solution and communicative saline well

Well number	NaCl (g/L)	Na ₂ SO ₄ (g/L)	CaSO ₄ (g/L)	MgSO ₄ (g/L)
29-30	294.50	51.71	0.67	0.28
32-33	307.15	32.78	0.80	0.25
21-28-22	257.87	42.85	1.26	0.12
5-7	306.68	32.68	1.13	0.15

HYDRAULIC FRACTURE

Hydraulic fracture produces the crack by artificial method. In the other word, there is two wells, one is the main killing well the other is killed well. Fracture liquid is pumped into the main killing well by high-pressured reciprocating pump. The rock salt is cracked along with the increasingly pressure. After

cracking, injection pressure drops sharply, the water enters the main killing well increases greatly, the outlet brine from killed well also goes up a lot. The connection between the main killing well and killed well is formed.

There are four fracturing theories for hydraulic fracturing, which are thick wall tube theory, permeable pressure head theory, break along with the natural fracture hypothesis, plastic deformation fracture theory. In order to

suit the extension project of 300,000 tons co-production of salt and Glauber's salt in 1996 years, 15 new wells were built in working area. Among it, Y well group was designed as the fracture well group with right triangle arrangement, the main killing well was arranged below the rock layer tendency and along the salt layer tendency and moving towards, two well were arranged in order to outlet the brine. Because there was no any fracturing unit at that time, in addition, the supplement of brine is not enough, without fracturing treatment. Y well group produces according to the single well counter-flow well respectively. Finally new 1 and Y3 saline well connect in directional-butted, new 2 and Y2 saline well also connect in directional-butted.

DIRECTIONAL BUTTING AND COMMUNICATION BRINE WELL

Directional butting and communication brine well general is a well group with two saline wells. The mechanical energy, which drives drill bit engraving and taking the rock, is transformed from pressure energy of the high-pressured liquid, which is sent by surface mud pump, through screw drill. The mechanical energy is used to construct smooth circular-arc path. According to the horizontal well with middle or small radius of curvature, directional drilling is processed towards the target well (vertical well). Or drill the

horizontal well with middle or small radius of curvature among those two saline wells toward the same target which is designed and opposite. These two wells is interconnected at the predetermined target in the appointed ore bed, with 0.5° - 0.7° /m whipstocking capacity. The directional drilling may interconnect the new well with new well or the new well with the old well.

Butting and communication between the new well and the old well

The butting technology of directional drilling is firstly applied for the salt mine in 2000 in Jiangxi, 5 pairs of convective producing wells with directional wells and single wells interconnected successively. Because the accident rate of single well convection production is high, and after multiple repair of brine well the mining level uppers shift, the cavity roof generally located at 30th salt bed, in addition, the position of straight section of directional well products casing cementing is about 800-900 meters, which is the upper ore layer, (because the butting path has about 60 meters horizontal sections through 36th salt bed, so the initial period production effect is good). As a result the content of bittern sodium sulfate is rising commonly nowadays, which cannot satisfy the original brine quality request. The related data is shown in Table 2.

Table 2. Analysis on the brine quality by butting and communication production with directional well and old well.

Well number	Time	NaCl (g/L)	Na ₂ SO ₄ (g/L)	CaSO ₄ (g/L)	MgSO ₄ (g/L)
3- new 1	2001	307.69	13.52	2.55	0.21
	11-2007	304.94	37.60	0.83	0.20
2- new2	2001	301.52	20.52	2.11	0.19
	11-2007	304.94	37.64	1.12	0.25
10- new 3	2001	304.97	16.73	2.23	0.25
	11-2007	230.38	36.05	1.95	0.26
13- new 4	2004	300.13	6.08	3.62	0.12
	11-2007	304.38	34.09	0.90	0.13
15- new 5	2004	302.87	13.68	2.59	0.25
	11-2007	305.47	25.86	0.83	0.13

Note: Well distance: 178-240 m

The butting and communication of new well and new well

One new well is the goal well, drifting is the straight section. Another new well is directional-butted well. After the vertical well is built completely, enter the central tube by the single well convection production testing to build salt cavity. After fix the well of the directional well straight section, directional drilling along with the goal well (vertical well), enter the target spot. That is butting and communication.

In the mining area, two pairs of directional well and new well butting and communication successively, they are new 6-new 7 and new 8-new 9. According to material analysis on the build of new 6-new 7 well, the new 6 well (goal well) located above the salt bed tendency place, the casing pipe located at number 36 salt bed, the new 7 well (directional well) located under the salt bed tendency place, the casing pipe located at

number 22 salt bed, the directional path passes through from number 22 to number 38 salt layers. When brine-extracted production enters water through new 7 well, because of the concentration difference and its big dissolution velocity, the upside exposed number 22, 23, 24 salt layers are dissolved firstly. While brine extraction dissolves the rock layer, the glauberite mineral is also dissolved. As a result the output brine has a high content of sodium sulfate. When brine-extracted production enters water through new 7 well, the number 36, 37, 38 salt layers are dissolved firstly. The content of glauberite is relatively low, so the content of sodium sulfate in brine is also low. To produce the brine with entering the water, new 6 well is better than new 7th well obviously. According to the different operating type, analysis on the brine quality of is shown in Table 3.

Table 3. Analysis on the produced brine quality by new 6 well and new 7 well

Operating type	Time	NaCl (g/L)	Na ₂ SO ₄ (g/L)	CaSO ₄ (g/L)	MgSO ₄ (g/L)
Inlet water through new 7 well, outlet brine through new 6 well	2006.1	305.09	28.74	1.38	0.15
Inlet water through new 6 well, outlet brine through new 7 well	2006.6	307.72	8.51	3.08	0.20

Note: well distance: 240 m

UNDERSTANDING

1. The natural solution and communication brine well do not have a big significant in Jiangxi salt rock.

2. The directional drilling communicated well pair is the best choice of exploitation process in this working area.

3. The directional well group should be arranged along with the salt bed tendency, the vertical well is arranged below the salt bed tendency and the the directional well is arranged above the tendency.

4. The well space of directional drilling communicated well pair is between

260 to 300 meters for suitable.

5. To increase the recovery ratio of ore, reduce the content of sodium sulfate in bittern, put the casing pipe of target well into the salt layer roof of number 40 well. The straight section of directional well is 950-960 meters, Put the casing pipe into number 28-30 salt layer, the directional path arrives at the first target (48 salt deposits), then pass through the middle of No. 48 salt deposits, directly arrives at the second target well, the horizontal section will amount to about 150 meters.

6. After directional butting and communication, the directional well is mainly used to enter the water for production. After

the directional connection channel expands (produces about 1 month), then the well can produce steadily.

7. While the directional butting and communicated saline well regular products, the salty content of outlet brine normally is above 320 g/L. In order to prevent blocking

the well by the salty crystals happens, open the water valve to flush the brine pipe for 20 min every day should be fixed.

8. According to the quality of outlet brine from the wells, second mixed mining can be carried on to guarantee the brine quality by Glauber salt production.