

THE APPLICATIONS ON TECHNOLOGY OF CONNECTED BRINE WELLS IN THICK ROCK SALT LAYER

Huang Cunmo
Jiangxi Salt Mine Ltd.

Abstract: The application of the connected brine wells were most used in the area of thick rock salt. In Jiangxi salt mine, the rock salt laying with multiple layer salt. For the natural connection and fracture connection could not get the salt is factory effects, they have built three new brine wells to connect different old brine wells with the technology of the connected brine wells, and have been getting the good economic effects and social effects.

Key words: Connected wells; Rock salt mining; Multiple layer; Application

PREFACE

Jiangxi salt mine is one of national key enterprises in the large-scale production of edible purification iodized salt. It expands the commissioning with co-production line of salt and Glauber's salt in May 1996, the annual yield of the fine salt is 300,000 tons, the thenardite is 20000 tons, which is at international advanced level in the 90s. Along with expansion of production scale and the increasing requirement of bittern quality with the advanced processing technology of co-production of salt and Glauber's salt, the relative backwardness situation in Jiangxi salt mine with single well convection mining processing technology is obviously prominent. Because the critical lack of bittern and the bad quality, once affected the regular production in Jiangxi salt mine. In order to solve the problem of bittern supplement completely, the technological transformation to the Jiangxi salt mine mining process is urgently needed.

MINING AREA GEOLOGICAL FEATURE

Jiangxi salt mine working area belongs to the north section of Qingjiang salt mine. The north section structure is simple as monoclinical structure, it is one direction, towards N60°E favors SE, the inclination angle is 3°~7°. The ore body assumes to be layered or resembles layered, burying depth is in the range of 592.92~1107 meters.

The fracture in the area does not grow. There are three fractures which had been

discovered: Zhong Guoli normal fracture, an old brook fracture.

The cutting through stratum in the ore section reveals the quaternary and the lower tertiary from the top to bottom. The lower tertiary is composed of the Linjiang group and Qingjiang group. The rock salt ore body is existed in the middle and upside of Qingjiang section. In the ore section, salt bed was only cut through until the 44th. According to the rock property and deposition characteristic of the rock salt, the salt bed which was cut through in the ore section is divided into three

rock salt groups. The thickness of first salt rock group is approximately 38.5~92.10 meters; The thickness of second salt rock group is approximately 59.3~93.50 meters; The thickness of third salt rock group is 90~113 meters.

The main chemical composition of rock salt ore in north section includes: NaCl, Na₂SO₄, CaSO₄, MgSO₄ and so on.

The brine supplement base of vacuum salt-making with annual yield 300,000 tons after the expansion of Jiangxi salt mine, is

located at the south place (1.5~2 kilometers) of old working area. They are all at the north section edge of north section. The first mining area is 1.5 square kilometers, the rock salt ore body generally is below 750 meters. Until now, the cutting through only achieves at the 40th salt bed, the interlayer in rock salt band mostly is mudstone, the thickness generally is 4~7 meters, which is easy to collapse. The salt bed accumulated average thickness and the NaCl average grade of the first mining area are shown in Table 1.

Table 1

Salt group number	Salt layer number	Salt layer accumulated average thickness (m)	NaCl average grade (%)
1	1—14	21.91	65.59
2	16—28	33.54	71.90
3	29—40	24.05	74.17
First mining layer	35—40	13.78	72.21

THE INTRODUCTION AND APPLICATION OF BUTTED WELL TECHNOLOGY INTO JIANGXI SALT MINE

Original mining method in Jiangxi salt mine

The mining methods used in Jiangxi salt mine was single well convection mining processing technology ever since a long time ago. In the 80s, the fracture method was tested in the old well, but the result does not so good. To the 300,000 tons extension project, mine plans to select the combination of "single well convection gradient mining primarily assisting with communication of two wells (fracture)" as the mining method. In order to satisfy the request of extension project mining, open up a new ore-district base on the original 100,000 tons mine foundation. Build 15 brine wells, and one of the fracture well group* (Y-) is arranged in triangle according to the ore layer tendency. The well spacing is controlled in 80~100 meters. The natural corrosion connection well group and the single convection well adopted the linear arrangement basically, the well spacing

generally is controlled in 50~80 meters, the set distance is controlled in 200 meters. 15 brine wells had began to construct since September, 1995, and had completed in December, 1997. After that, it changes over to the trial production. Because the original designed fracture well group do not have mature technology in this type of mineral resource, so it changes over to the single well convection. Through several year's production practice, the mining method as single well convection adopted by Jiangxi salt mine was proved bad once more. The bed effects include bad brine quality, low mining ability, difficult to manage, many accidents happen in the well, high invests and so on. As a result, it restricts the regular production and economic efficiency of the enterprise seriously.

The selection of the ground orientation and well drilling docking technology

Through the inspection to the vanguard technology of butting of dual well and the analysis and comparison on each kind of mining process, the "ground controlled directional well drilling technology" was decided to be used. This technology won the

national significant scientific and payoffs. It has many advantages, such as mature technology, short construction period, an immediate effect, low risk and low investment. It also connected two wells directly, thus achieves the target of brine extraction with communication of two wells.

Well site

The technical requirement of docking brine well was satisfied. Because there are many single convection wells in Jiangxi salt mine presently, the 15 wells constructed in the extension project put into operation to produce brine not so long. Some cavities are still available. Additionally, the central tube is still in the first mined layer 35-40 salt bed and the

intermediate casing is quite complete. According to the present production situation, economy bearing capacity and development request, dock three directional wells (new 1, new 2, new 3) with three old wells (Y-1-3, Y-1-2, D-2-1) separately was designed. As a result of the terrain landform does not affect the arrangement of docking well, the ore layer is gentle in this mining area. Therefore the well placement had mainly considered about the utilization of the mineral resource, the environment influence, the execution conditions, the mine management, direct and indirect economic efficiency s and so on. The new 1 well and the new 2 well arrangement can be seen in Figure 1.

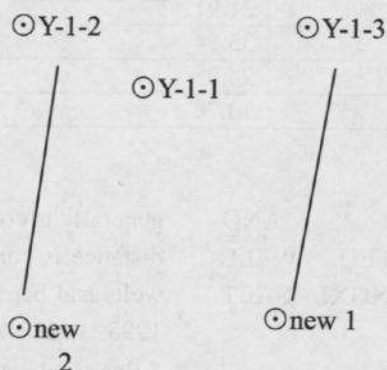


Figure 1

Table 2

Well number	Well completion depth (m)	Depth of technical pipe (depth before interconnection) (m)	Depth of central pipe (depth before interconnection) (m)	Salt yield (ton)
Y-1-3	1003	965(940)	980.2(977.87)	30605.0
Y-1-2	1001	958.59(958.59)	990.6(990.70)	7042.0
D-2-1	1008	977(960.33)	1007.52(1006.79)	12445.0

Construction design requirement

Three directional docking wells have to directly put into the cavity of three old brine wells separately. The ground distance is around 180 meters, the length of whipstocking is approximately 280 meters, the length of horizontal section is bigger than 50 meters, target is in the 35-40 salt beds of first mining layer.

The demanding of errors are: straight section $\leq 0.5\%$, well inclination $\leq 2.5^\circ/100\text{m}$, azimuthal error $\leq 45^\circ/30\text{m}$. Drill through the quaternary bed rock above 10 meters, Underside surface pipe $\phi 219 \times 8$ mm is drilled continuously with high mark cementing well, the final depth of the hole at least is cutting through 1-2 salt layers (approximately about 800 m, according to the real drilling situation, the technical pipe should be guaranteed

entering the interlayer of the rock). Put in the technical pipe $\phi 114.3 \times 6.35$ mm, install the centralizer, cementing well with grade G oil well. Through the testing and inspection of straight section well completion and well

cementation quality, its quality is in accordance with well drilling technology standard of well rock salt. The casing program is shown in Figure 2. (take the new 3 well as an example).

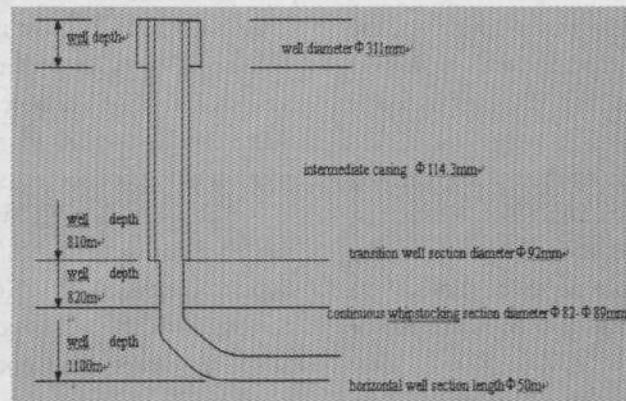


Figure 2 Casing program diagram

Whipstocking drilling construction **The major installation and instrument used in whipstocking drilling (see in table 3)**

Table 3

Name	Specifications and models	Amount
Drilling machine	Ligen TXL-1E	1
Mud pump	NBB-250/60	2
	BW320	1
Wire line core drill pipe	$\Phi 70\text{mm}$ $\Phi 55\text{mm}$	1200
Screw drill	$\Phi 70\text{mm}$	2
	$\Phi 65\text{mm}$	4
Curved outer tube	$0.5^\circ \sim 2.5^\circ$	5
Whipstocking diamond drill bit 、 whipstocking PDC bit	$\Phi 89 \sim \Phi 82\text{mm}$	8
Non-magnetic drilling pipe	$\Phi 58\text{mm}$	1
Orientation inclino meter	OWL-780	1

Whipstocking construction situation

During the whole drilling process, the number of times of raising the drills are relatively quite a lot, the process went quite well, no hole accident were happened, the rock salt layer and interlayer were quite stable, the mud preparation was ideal, lose was few. The reasons are that, many thin salt layers, the interlayer is thick and hard, the well is slowest, the loss of screw rod and drill bit is quite large.

The new 1 well whipstocking drilling started from December 25th, 1999, 09 meters, in January 10th, 2000, directly put into the Y-1-3 cavity at the hole depth of (hole long) 1069.23 meters, docking salt bed is at number 36 salt bed.

The new 2 well whipstocking drilling started from June 7th, 2000, the hole depth is 810.07 meters. The docking at 1083.60 meters was not completely until July 3rd, 2000, the docking salt bed is at number 37 salt bed. Because the cavity of Y-1-2 well docking target is small, the computation accumulative

error of drilled path surpassed the real radius of the cavity. As a result, drill to the 1092 meters hole depth, the wells were still not able to be connected in June 23rd. Afterward, adjust the program immediately, and carried on the data processing to the Y-1-2 well and the new 2 well. On June 27th, the new 2 well sealed the hole at 1030~1060 meters section, on July 1st sidetrack drill at the hole depth 1033 meters. After drilling to 1083.66 meters and two wells were docking connected, stop the hole.

The new 3 well whipstocking drilling started from Oct. 7th, 2000, the hole depth is 800.16 meters. Until Nov. 5th, 2000, it is connected with D-2-1 well at the hole depth 1083.60 meters. The docking salt bed is at number 37 salt bed.

The main technique target of three directional butted wells can be seen in Table

Table 4

Butted well number	Well distance between two wells(m)	Final Well length (m)	Average Builtup rate (°/m)	Horizontal hole section size (m)	Docking point synthetic error (m)	Hole Completion date	Present brine (m ³ /h)	Brine quality (g/L)	
								NaCl	Na ₂ SO ₄
New 1~Y-1-3	176.4	1069.23	0.4~0.7	60.0	0.86	2000.1	63	298	15
		1003	Old brine well						
New 2~Y-1-2	187.8	1083.6	0.4~0.7	65.0	1.06	2000.7	55	295	17
		1001	Old brine well						
New 3~D-2-1	183.0	1072.35	0.4~0.7	60.0	1.00	2000.11	50	300	15
		1018	Old brine well						

PRODUCTION TEST SITUATION

Production test requirement

1 After two wells are interconnected, the pipelines have to be connected as soon as possible to start brine extraction. In order to prevent the rock powder block the drilling hole channel.

2 For the purpose of reducing the pressure drop of the ground pipeline, its inner diameter needs to be larger than the underground pipeline as far as possible and needs to be guaranteed that the pipeline connection is leakproof.

3 The centrifugal pump with pumping head is higher than 600 meters and the flow rate is not lower than $50 \text{ m}^3/\text{h}$ is selected.

4 Construct cavity continuously, and often observe and record.

5 Since the fresh water or diluted brine is poured into the new well, the injection pressure can not lower than 4MPa and exit pressure can not lower than 0.15MPa. After the new well drill hole channel meets certain requirement, the water can be injected from the old well. During the period, inject water to the new well to prevent crystallizing.

Production test result

Because the old well has a certain cavity, the designed requirements can be reached after one week production test of three pairs of connective wells, and the qualified bittern is produced. Along with the time passing, the channel expands gradually, the flow rate is $\geq 55 \text{ m}^3/\text{h}$ and the content of NaCl is $\geq 295 \text{ g/L}$ at present.

ECONOMIC BENEFIT

The advantages of butted and communication well are reflected again in Jiangxi salt mine, which include low investment, high mineral resource recovery ratio, low cost of brine extraction, high concentration of brine, stable quality, easy to manage the mine, long lifetime of the brine well and so on. The using of butted and communication wells basically satisfied the production request and played an important role in the stable production and the increasing economic benefit in Jiangxi salt mine. Every year it may save the investment of the well contraction, reduce the repair expense of the brine well, reduce the energy consumption, increase the yield and so on. So it brings several million Yuans to the enterprise. What is worth mention are that it also occupied less farmland, reduced the environmental pollution, used in reasonable and protected the mineral resource.

CONCLUSION

1. The brine extraction technology of pair brine wells or multi-brine wells "ground orientation, well drilling docking" was mostly used in the rock salt bed whose thickness is quite high. Jiangxi salt mine is the first one to successfully apply this advanced technology in Jiangxi province. The successful application confirmed the universality of this technology and set an example of mining for the Qingjiang salt field whose rock salt bed is multilayer, thin or very thin layer.

2. Because the arrangement of the docking well does not affect by the landform, and the direction of the drilling can be controlled, so it plays an important roll in the aspects of solving the fault well and mining the covered ore deposit, etc.

3. Three directional salt deposits are exposed. If the cavity formed from upper salt layer or the collapsing of the rock salt interlayer influence brine extraction, whether the salt layer collapsing can progressively lift up or not, the size of the cavity and the final recovery ratio need to be observed and researched further on.

The science and technology is the first productive forces. Promote and apply the new technology as early as possible, as a result the benefits can be obtained early. In the end of 20 century, Jiangxi salt mine finally enabled to change the situation of low mining capacity, which troubled the enterprise's development for a long-time. It found a ideal mining way for multiple layer and thin layer salt rock. The change from the mining technology of single well convection to the mining technology of pair brine wells or multi-brine wells "ground orientation, well drilling docking", enables the mining technology of our mine achieve the domestic advanced level in the 90s. Additionally, it laid a strong foundation to the steady increasing of the enterprise's economic benefit.