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Development Status of Drainage Gas Recovery Technology in High Sulfur Gas Wells

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Abstract: *Due to the particularity of its stratigraphic structure, Sichuan Basin is rich in natural gas resources. With the production of gas wells, effusion is bound to occur in the wellbore. Once water invasion occurs, it will lead to the decline of natural gas production and even shutdown of the wells. Therefore, timely drainage of water in the wellbore is the key to restoring gas well production. Because of the high sulfur content of natural gas in Sichuan Basin, the conventional gas well drainage measures are difficult to apply, and some special drainage measures need to be taken. This paper mainly reviews the development and present situation of drainage technology for gas wells with high sulfur content, and introduces four main types of high sulfur gas well drainage gas recovery technologies: plunger gas lift, tubing perforation, electrical submersible pump drainage gas recovery technology, and foam drainage gas recovery, and compares their applicability, advantages and disadvantages.*

Keywords: *Sichuan Basin; Gas Well, Sulfur Content; Water Intrusion; Drainage Gas Recovery*

1. Introduction

In recent years, with the development of natural gas resources in Sichuan Basin, the water intrusion has gradually increased, and even caused the water flooding of some gas wells [1]. For the normal production of gas wells, gas well drainage is particularly important. There are various types of drainage gas production processes. At present, Sichuan Basin has gradually changed from a single drainage gas production process to a composite drainage gas production process. And has developed composite processes such as foam gas lift and plunger gas lift [2]. Since most of the gas wells in Sichuan Basin are sour gas wells, the sulfur content of natural gas is high [3]. And the permanent packer of sour gas wells leads to the sealing of oil jacket annulus, so the conventional drainage gas production process is difficult to implement effectively. Therefore, the drainage gas production process suitable for high sour gas wells has become the key point.

At present, the commonly used drainage gas recovery processes for sulfur-bearing gas wells are plunger gas lift [4], tubing perforation gas lift [5], electrical submersible pump drainage gas recovery technology [6], and foam drainage gas recovery [7]. Different processes for different conditions produce water for gas wells, which have certain requirements for water production and well structure of gas wells, resulting in certain limitations in the implementation of the technology. Therefore, this paper introduces the above four drainage gas production processes, points out their process requirements and makes a comparative discussion.

2. Plunger Gas Lift Process

2.1 Process Mechanism and Applicable Conditions

Plunger gas lift drainage gas production is to add a solid interface (plunger) between the gas and liquid phases, so that the gas below the plunger pushes the plunger upward, which will not affect the liquid phase above the plunger. Due to the existence of the plunger, the upper liquid will not fall, which increases the drainage efficiency [8]. Plunger drainage gas production is to use the energy of the gas well to push the plunger to move periodically in the tubing. There is no need to provide additional power source, which has certain economy. Since the plunger system is in direct contact with the high sulfur gas in the wellbore, in order to avoid acid gas corrosion, all key components are made of high alloy materials. The system composition is shown in Figure 1, including surface device, movable plunger and down hole components [9], in which the surface device is mainly composed of additional valves, catcher, trigger rod, buffer spring and other components, and the down hole components are mainly composed of tubing stopper, buffer spring and packer.

The gas well implementing plunger gas lift needs to have a certain capacity, the well depth is less than 4000m. There needs to be a certain effusion space at the bottom of the well, and the ratio of daily liquid production to daily gas production is greater than 250. It is suitable for the production and drainage of intermittent flowing wells with small water production. At the same time, there should be no attachments on the inner wall of the tubing to avoid affecting the movement of the plunger in the tubing. Due to the high-speed movement of the plunger in the tubing, therefore, the tubing is required to be continuous and unblocked.

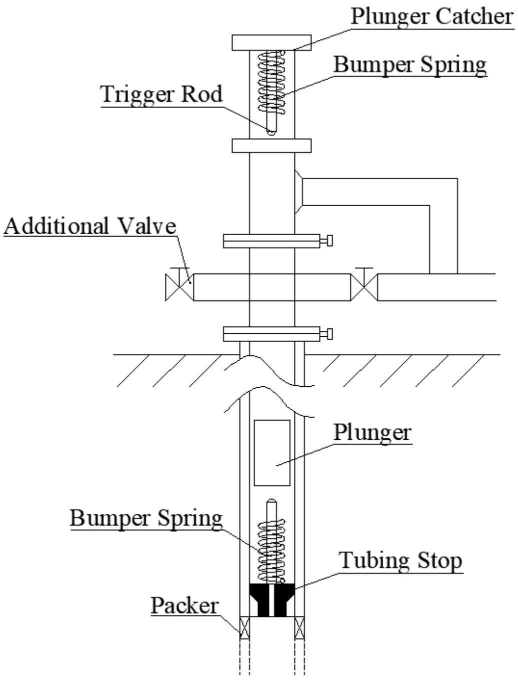

Figure 1: Conventional plunger lift system

2.2 Case Studies

In 2013, Zhang Junliang et al [8] studied the plunger lifting technology of sour gas wells for the problem of effusion in the wellbore of sour gas wells without a packer installed at the bottom of the well in northeast Sichuan. A comparative experiment was conducted in TS12 and L12 wells (Table 1), using a time-controlled mode to control the TS12 well to run for 9 cycles per day and the L12 well to run for 5 cycles per day. The results showed that the gas production of TS12 well increased by 28.6% and the gas production of L12 well increased by 8% on average.

Table 1: Comparison Experiment between TS12 and L12 Wells

Situations	Wells	Oil pressure (Mpa)	Sleeve pressure (Mpa)	Daily gas production (10^4m^3)	Daily water production (m^3)
Before plunger gas lift	TS12	5~6	10~11.5	1~1.1	12~13
	L12	5~5.5	7~8	1.1~1.4	4~5.5
After plunger gas lift	TS12	2.2~8	8~11.6	1.2~1.5	11.5~15
	L12	5~6.5	7.6~8.8	1.2~1.5	3~4

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3. Tubing Perforation Gas Lift Process

3.1 Process Mechanism and Applicable Conditions

Tubing perforation gas lift drainage technology establishes a new oil jacket circulation channel by drilling on the tubing and using the perforated hole as a simple gas lift valve to cooperate with the operation of ground equipment for gas lift drainage [10]. It does not need additional production tools and has low cost. However, since the design of perforation depth involves the superiority of drainage gas recovery, finding the best perforation point is the key to the gas lift drainage technology of tubing perforation.

The implementation of the tubing perforation gas lift drainage technology does not need to replace the string, but due to the small perforation hole, the starting pressure during gas lift is high. And the strength of tubing will be reduced due to tubing perforation.

3.2 Case Studies

In 2014, Yi Jin et al [5] studied the tubing perforation gas lift drainage technology for the problem of fluid accumulation in the wellbore of sulfur-bearing gas wells in Longgang Reef. The buried well depth of Longgang Reef gas reservoir is 4823 ~ 6261m, the formation temperature is high (140 ℃) and the formation pressure varies widely (25 to 61 MPa). The test well Longgang 001-18 has been in a water-flooded and shut-in state before the implementation of tubular perforated gas lift.

The Longgang 001-18 well was successfully achieved recovery and resumed production after gas lift drainage technology of tubing perforation. The highest daily gas production is 15.38×104m3 and the highest daily water production is 271m3 at the initial stage. As of early June 2012, the working condition of the compressor was stable, the oil pressure was stable at 10.5MPa, and the average daily gas production was 2.5×104m3, the average daily water output was 180m3. It realized a cumulative gas production of 357.96×104m3, and the cumulative water production is 13264m3.

4. Electrical Submersible Pump Drainage Gas Recovery Process

The electrical submersible pump drainage gas recovery technology involves placing centrifugal pumping equipment in the fluid accumulation section at the bottom of the well and pumping the accumulated fluid to the wellhead for discharge, resulting in the resumption of production from a shut-in gas well [11]. The electrical submersible pump needs to be lowered into the fluid accumulation section of the wellbore with the cable, and the deeper the well, the higher the cost. Therefore, it is suitable for gas wells with shallow well depth and serious ponding.

The implementation of electrical submersible pump drainage and gas production technology requires regular maintenance of the electrical submersible pump, with an average pump inspection period of 2 years. To avoid the damage of underground sand, gravel and scaling to the electrical submersible pump. At the same time, the electrical submersible pump cannot be run into the gas well in the slim hole, so the electrical submersible pump drainage and gas production technology is not applicable.

In 2018, Pengyang and others conducted a large number of research on the drainage technology of high sulfur gas wells. Due to the shape parameters of the electrical submersible pump, the process is only applicable to the large casing (with an outer diameter of at least 177.8mm). Due to the influence of acid gas, a canned electrical submersible pump system is designed to run into the ponding well section together with the tubing. Canned electrical submersible pump mainly includes cable traversing system, canned system, tubing sealing assembly, packer, etc., as shown in Figure 2.

The joints of canned electrical submersible pump are made of stainless steel, and the shell is coated and coated for anti-corrosion. When the electrical submersible pump is running, the fluid enters the tank from the internal channel of the packer, and then is pumped into the tubing until it reaches the ground. The canned electrical submersible pump system provides a technical basis for the implementation of electrical submersible pump drainage and gas production process in high sulfur gas wells.

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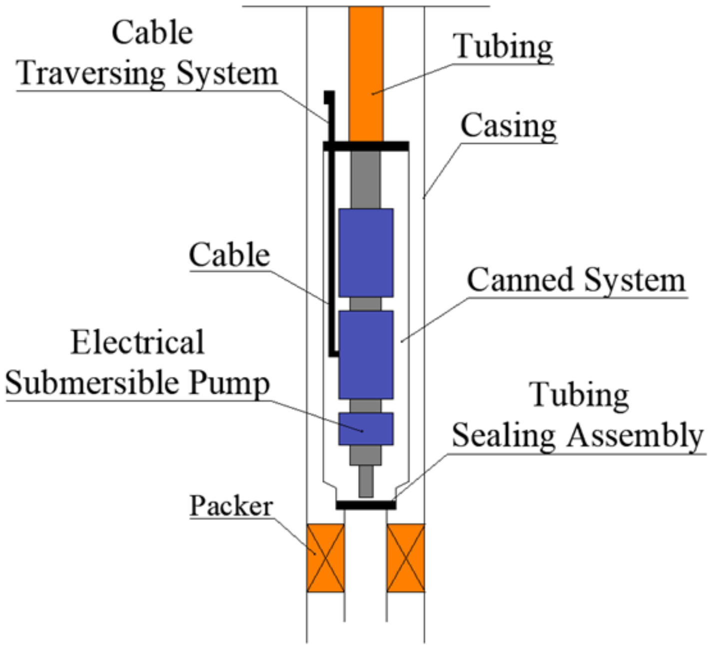

Figure 2: Underground Schematic Diagram of Canned Electrical Submersible Pump

5. Foam Drainage Gas Recovery Process

5.1 Process Mechanism and Applicable Conditions

Foam drainage gas recovery [12] is adding foam agent to the bottom of the well and mixing with water to produce light foam. The surface tension of the foam is much smaller than that of pure water, and the smaller the foam surface tension is, the higher the foam concentration is. With the flow of gas, the bubble discharge agent is fully contacted with the water, resulting in foam to change the flow pattern in the wellbore, so that the liquid carrying effect of the gas well is raised, and the liquid can be taken out of the wellhead to achieve the purpose of drainage and gas recovery.

Foam drainage gas recovery technology has strong applicability and can be applied to directional wells and complicated geological conditions. Because the foam drainage agent added to foam drainage has certain requirements for temperature and airflow velocity, the bottom hole temperature is generally less than 120 ℃. The minimum flow rate of air flow is required to be greater than 0.1m/s, which is applicable to weak and intermittent producing wells.

5.2 Case Studies

Puguang gas field in Sichuan is a typical high sulfur gas well. Permanent completion is used for string completion, and foaming agent can only be filled through tubings. When the foam discharge agent is liquid, most of the foam discharge agent is attached to the pipe wall and cannot reach the bottom of the well to mix with the effusion, resulting in insufficient effective dose of foam discharge agent, poor liquid discharge effect and waste of foam discharge agent. If the special coiled tubing is used to directly add the foam drainage agent to the bottom hole, the problem of foam drainage agent adhesion can be effectively solved. However, due to the high sulfur characteristics of the gas well, it will cause corrosion damage to the coiled tubing and cannot be operated for a long time. Therefore, Chen Yongguang et al[13] designed solid foam discharge agent to solve the problems caused by foam discharge agent injection. So it is the best for the filling of Puguang gas field.

In 2019, Chen Yong Hao et al[14] carried out the adaptability of the foam drainage gas recovery technology in the high sulfur gas well in Puguang gas field, and compared the experiments of Puguang P305-2 and P103-1. The test results are shown in Table 2. The bubble drainage effect is good. After bubble drainage, the oil pressure of wells P305-2 and P103-1 has increased by 9.8% and 12.8% respectively. The daily gas production increased by 28.6% and 25% respectively. The increase of daily liquid production was the most obvious, 86.2% and 80% respectively.

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Table 2: Test Results of Two Wells P305-2 and P103-1

Situations	Wells	Oil pressure (Mpa)	Daily gas production (104m3)	Daily water production (m3)
Before foam drainage gas recovery	P305-2	11.2	7	2.9
	P103-1	9.4	12	25
After foam drainage gas recovery	P305-2	12.3	9	5.4
	P103-1	10.6	15	45

6. Conclusion

The drainage gas lift process of conventional gas wells has become more and more mature after years of development, but the drainage gas production process for high sulfur gas wells has just started with many difficulties and challenges. At present, most sour gas wells adopt single drainage gas production process, with obvious applicable conditions and disadvantages. Plunger gas lift, tubing perforation, electrical submersible pump drainage technology, and foam drainage gas recovery four main high sulfur gas well drainage gas recovery technology in the future will also change to a composite drainage gas recovery process to make up for the defects of a single process. In addition, the continuous innovation of technology is the basis of oil and gas growth. Therefore, the drainage and gas production process of high sulfur gas wells needs to be continuously explored by researchers.

References

[1] Wu Kang, Ma Faming, Shi Ying. Current status and developing direction of gas recovery techniques in sichuan basin [J]. Natural Gas Industry, 2005, 25(3):113-117.
[2] Huang Yan, She Chaoyi, Ma Huiyun, et al. Research and application of drainage gas recovery technology in sichuan gas field [J]. Drilling & Production Technology, 2008, 31(5):66-69.
[3] Liu Xiangkang, Wang Chuanlei, Ding Liangliang, et al. Failure probability analysis of barrier components in hthp sour gas wells [J]. Science Technology and Engineering, 2021, 21(12):4905-4910.
[4] He Shunli, Wu Zhijun. Analyzing the influence factors of plunger gas lift and optimizing design [J]. Natural Gas Industry, 2005, 25(6):97-99.
[5] Yi Jin, Gu Youyi, Pan Yunbing, et al. Drainage gas recovery technology by tubing perforated gas-lift drainage [J]. Oil Drilling & Production Technology, 2014, 36(3):103-105.
[6] Peng Yang, Ye Changqing, Sun Fengjing, et al. Drainage gas recovery technology based on canned ESP system of high-sulfur gas wells [J]. Natural Gas Industry, 2018, 38(2):67-73.
[7] Liu Tong, Wu Xiaoding, Zhu Jiang, et al. Practice of deliquification technology in high-sulfur gas fields in puguang and yuanba [J]. China Petroleum Machinery, 2020, 48 (11): 84-89.
[8] Zhang Junliang, Wang Yang, Ren Yang, et al. Application of the plunger lift drainage gas recovery technology in sour gas well [J]. Reservoir Evaluation and Development, 2013, (1):50-54.
[9] Shen Jian, Qiang Yanlong, Chen Xiancui, et al. Research and application of plunger gas lift liquid extraction process technology [J]. Inner Mongolian Petrochemical Industry, 2005, 31(8):112-113.
[10] Li Changbo, he Hailin, Lu Yuangao, et al. Discussion on gas lift drainage gas production technology with tubing perforation [J]. Chemical Enterprise Management, 2020, (6):119-120.
[11] Xiong Jie, Wang Xueqiang, sun Xinyun, et al. Research and application of drainage gas recovery technology by electrical submersible pump in deep gas well [J]. Drilling & Production Technology, 2012, 35 (4):60-61.
[12] Zheng Rui, Liang Jing, Li Ying, et al. The cloud monitoring system of wellhead foam content used for foam drainage gas recovery wells [J]. Natural Gas Industry, 2021, (S01):171-176.
[13] Chen Yongguang. Solid foam drainage technology for high-sulfur gas wells in Puguang gas field [J]. Inner Mongolia Petrochemical Industry, 2017, 43(4):94-96.
[14] Chen Yonghao. Study on technology of foam drainage and gas recovery in high sulfur gas well [J]. China Petroleum and Chemical Standard and Quality, 2019, (16):217-219.