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Research and application of gas lift technology in bedrock gas reservoirs -A case study of Jianbei gas reservoir

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Abstract

The Jianbei gas reservoir, situated in the Altun Mountains of the Qaidam Basin, is a typical bedrock gas reservoir. Since its commissioning, the gas wells have generally encountered water breakthrough, leading to a significant drop in production. To address this issue, a pressurised gas lift process was implemented to drain water and boost production. While most wells exhibited positive production increases, some showed little to no change in productivity post-treatment. Therefore, it is imperative to investigate the reasons for these discrepancies and adjust/upgrade the original plan accordingly. Through comprehensive analysis from various perspectives, including fluid accumulation issues, the gas lift process itself, and wellbore structure, it was identified that the primary factors limiting the effectiveness of gas lift in the Jianbei gas reservoir are severe fluid accumulation in the wellbore, poor adaptability of the gas lift process in certain wells, inappropriate tubing size, and severe formation damage. To tackle these issues, the gas lift plan for the Jianbei gas reservoir was upgraded and optimised. Relevant parameters were redesigned based on tubing diameter optimization principles and gas lift characteristic curves, aiming to maximize the stimulation effect of gas lift. This approach effectively resolves the existing technical challenges and provides a solid scientific foundation and technical support for future gas reservoir management and development, ensuring optimal operation of the gas wells.

Keywords: Bedrock; Gas lift; Restrictive factors; Gas recovery by water drainage.

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1- Introduction

Bedrock gas reservoir, as a kind of unconventional gas reservoir, is widely distributed in the world. As early as the mid-20th century, 16 bedrock gas wells were discovered in Orth, Kansas [1], and bedrock gas reservoirs have been found in Venezuela, Indonesia, Libya, the United States and China [2]. Nowadays, the distribution of bedrock gas reservoirs in foreign countries mainly includes African Bonger basin and Indonesian Jatibalan basalt oil and gas field, while in China it is mainly Bohai Bay Basin, Songliao Basin and Qaidam Basin, the largest geological reserves are in the Dongping and Jianbei areas in front of the Altun Qaidam Basin discovered in 2012 [3]. The drainage and production technology of bedrock gas reservoirs is still in the development stage. because of its different depths, there are still many problems in gas lift, bubble drainage and mechanical mining. In this paper, some gas wells in the Jianbei gas reservoir will be studied and applied in bedrock gas reservoir.

Gas-lift drainage gas production technology is an important method in natural gas exploitation, which can effectively solve the problem of production decline caused by water out of gas well, prolong gas well production life, and improve the overall development benefit of gas field. In recent years, gas-lift technology has been used in many oil fields to increase production of oil and gas wells effectively, such as Brent [4] and others have explored the combination of gas-lift and plunger technology to create a solution for the whole life cycle production of oil and gas wells; Xiang Jin Yuan [5] and others have carried out the experiment of multi-stage gas-lift valve in Sulige gas field, and obtained the stage results; Tong Yu Qi [6] and others have put forward the new method of combined lifting of coiled tubing and gas-lift valve, partha [7] and others used plunger lift to increase the oil and gas production of several oil and gas fields in Upper Assam Shelf basin and reduce the related problems such as paraffin deposition Maaly [8] et al explored effective measures for gas-lift technology to maximize production in the Abu Ghirab oil field in south-east Iraq using continuous gas-lift through PIPESIM TM software; Nguyen [9] et al carried out dewaxing treatment in oil wells by gas lift process; Julian [10] et al. explored the results of gas-lift valve repair and cross-loading studies in large gas-lift oilfields; Soni [11] et al explored the implementation of the gas lift process in sour oil and gas fields; Taking Orenburg oilfield as an example, Yudin [12] et al developed a method to simulate a well by

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approximating the relationship between the flow velocity of a well and the flow velocity and linear pressure of gas-lift gas; Gunwant [13] et al designed several new gas-lift valves with convergent gas-lift ports, which solved the challenge of subcritical flow state in traditional valves; Ishak [14] et al put forward an economical and effective limited energy gas lift scheme, which can be used as a temporary measure to replace the shortcomings of gas lift system in oil field; Su [15] et al introduced the application of intelligent gas lift optimization (SGLO) workflow in complex giant onshore carbonate oil field, which can maximize production and recovery by high-efficiency gas lift optimization method; Akeil [16] et al demonstrated the effectiveness of smaller port sizes, virtual valves, and venturi valves in improving gas lift performance and maximizing oil recovery; Al [17] et Al introduced a case study of Khafji Joint Operation Oilfield, using intelligent digital gas-lift valve to optimize the design and performance of gas-lift wells; Maijoni [18] et al studied how to solve the production instability of gas-lift wells in transient (dynamic) and steady-state simulation of continuous gas injection; Elldakli [19] et al modified the gas-lift seat to address the problem that each injection-operated gas-lift valve (GLV) often cannot be fully opened in practice due to bellows stacking. In addition, there are many researches on gas-lift technology, which has gradually become the key technology to increase and resume production in oil and gas development.

Since the implementation of gas lift in the Jianbei gas reservoir, many wells have successfully resumed production, significantly promoting the recovery of production across the entire block. However, in recent years, the effectiveness of gas lift technology has gradually declined, and some gas wells have failed to meet their expected production targets. Therefore, this paper analyzes the main factors restricting the effectiveness of gas-lift technology based on production data from several gas-lift wells in the Jianbei gas reservoir. The gas lift technology scheme has been optimized and adjusted, with key parameters such as gas injection rate and pressure being redesigned. This aims to guide on-site processes and provide theoretical support and direction for the development of drainage gas production technology in bedrock gas reservoirs.

2- General situation of gas reservoir

The Jianbei gas reservoir is situated on the Jianbei slope structure in the eastern part of the Altun Mountains within the Qaidam Basin, bordered by Nanyishan and Xiaoliangshan to the west, Dongping gas field to the east, and Dafengshan structure to the south. It represents a typical bedrock-fractured reservoir in China, characterized by wells exceeding 5,000 meters in depth and temperatures surpassing 170°C. The formation of the Jianbei gas field is closely associated with the arc-shaped mountains protruding from the Arguin basin. The geological structure in this piedmont basin features high fault steps, a middle slope, low fault uplifts, and deep depressions. The Jianbei, Jiandingshan, and Jiannan faults are secondary faults that significantly influence stratigraphic distribution and the formation of paleo-uplifts. The Jianbei gas field hosts a variety of favorable traps, including structural traps (primarily anticlines, fault anticlines, and fault noses), as well as stratigraphic and lithologic traps. Additionally, bedrock traps are present in Qianshan County, further diversifying the types of reservoirs available. At present, the average oil pressure of the Jianbei gas reservoir is 2.59 MPa, the average casing pressure is 3.72 MPa, the daily gas production is about $1.29\times10^4 m^3/d$, the daily water production is about 166.13 m^3/d, and the water-gas ratio is 128.69 $m^3/10^4m^3$.

3- Study on gas lift technology of Jianbei gas reservoir

3.1. Process principle and characteristics

The gas-lift process involves injecting gas into the wellbore, either in a positive or a negative lift, in order to increase the velocity of the gas-phase fluid until a critical velocity at which the liquid can be effectively carried is reached. This process is aimed at removing the fluid accumulated at the bottom of the well and the fluid produced from the formation, thereby reducing the pressure at the bottom of the well and enabling the gas well to resume normal production. In this way, not only can improve the gas recovery speed be improved, but it also can increase the final recovery.

Gas lift technology is a highly effective method for drainage and gas recovery in water-bearing gas reservoir development. It is particularly suitable for addressing fluid accumulation in the wellbore, promoting the resumption of production in shut-down wells, and assisting gas wells with significant water production to drain fluids efficiently. One advantage of this process is its broad applicability, which is not limited by parameters such as gas well type, gas production rate, water production rate, or water-to-gas ratio. Additionally, since there are no mechanical moving parts, it remains unaffected by sand production or well type. Moreover, gas lift technology offers operational flexibility and wide-ranging applications, making it an essential tool for enhancing gas reservoir production efficiency.

Based on the differences in gas injection processes and ground equipment, the gas-lift process can be divided into two types: skid-mounted mobile compressor gas lift and centralized pressurization gas lift. The skid-mounted mobile compressor gas lift is characterized by its strong mobility, making it suitable for temporary or emergency use. However, this type of compressor is relatively small and typically can only provide gas lift services for one well at a time.

In contrast, the centralized booster gas lift involves establishing a dedicated booster station within the gas field, equipped with valve sets and a control system. A specialized gas-lift line is laid to each well requiring gas-lift operations. This approach enables automatic control and precise adjustment of the volume and pressure of gas injection for each well. It supports simultaneous continuous gas-lift operations in multiple wells, thereby improving operational efficiency and flexibility [5].

3.2. The restrictive factors of process effect

In recent years, many gas wells in the Jianbei area have implemented pressurized gas lift technology by injecting natural gas. According to the analysis of production data before and after the implementation of this technology Table 1, most gas wells have shown significant stimulation effects following the use of pressurized gas lifts. However, there are still some gas wells that exhibit no noticeable changes in production levels before and after applying this technology, and in some cases, both gas and water production have simultaneously declined.

In light of these observations, this paper aims to conduct an in-depth analysis from multiple perspectives to identify the constraints leading to these differences. By comprehensively considering factors such as wellbore fluid accumulation, process adaptability, and tubing size, we will explore the key factors affecting the performance of pressurized gas lift technology. Based on this analysis, we will propose corresponding optimization strategies. This approach not only seeks to enhance the production efficiency of existing gas wells but also provides valuable insights for the planning and implementation of similar projects in the future.

Table 1. Statistics of Jianbei pressurized gas lift wells (natural gas)

Well name	Process			After processing		
	Oil sleeve pressure difference (MPa)	Daily gas production ($10^4m^3/d$)	Daily water production (m^3/d)	Oil sleeve pressure difference(MPa)	Daily gas production ($10^4m^3/d$)	Daily water production (m^3/d)
Jian 3	2.46	0.2	11.12	2.47	0.24	10.08
Jianbei 1-2	3.95	0.12	0	3.11	0.15	1.52
Jianbei 1-3	6.79	0.87	80.9	6.59	0.58	119
Jianbei 1-4	3.57	0.32	19	3.79	0.31	19.07
Jianbei 1-5	3.7	0.28	13.1	3.59	0.26	12.99
Jianbei 1-7	10.72	0.0144	0.4	10.32	0.0716	20.4
Jianbei H1-3	3.08	0.196	19.2	3.56	0.2	16.4

(1) Fluid accumulation in the wellbore

Excessive fluid accumulation in the wellbore is one of the key factors affecting the effectiveness of pressurized gas lifts, particularly in bedrock gas reservoirs. Gas wells that show limited improvement after implementing pressurized gas lifts are often characterized by significant fluid accumulation. According to the comparative analysis of Fig. 1, Fig. 2 and Table 2, it is found that when the liquid loading height is too high, it may lead to gas locking; that is, the liquid hinders the smooth flow of gas, thus significantly reducing the productivity of the well. Moreover, excessive fluid accumulation increases the energy consumption required for process operations and diminishes overall efficiency.

Table 2. Statistics of liquid accumulation height and gas injection parameters in Jianbei

Well name	Height of fluid accumulation (m)	Injection pressure (MPa)	Volume of gas injection ($10^4m^3/d$)	Gas production ($10^4m^3/d$)	Water yield (m^3/d)
Jianbei 1-2	1021.94	5.8	1.02	0.15	1.52
Jianbei 1-4	2151.15	9.01	4.44	0.31	19.07
Jianbei 1-5	2382.52	8.47	4.62	0.26	12.99
Jianbei H1-3	2370.07	8.2	5.98	0.2	16.4

(2) Mismatch of process adaptability

The main technical limits of the pressurized gas-lift drainage and production technology are embodied in two key aspects[20-22]:

1) Bottom-hole flowing pressure: As gas and water production increase, the pressure drop within the wellbore also rises. If the wellhead pressure falls below the minimum level required for normal transportation, the gas well cannot maintain stable production under the specific bottom-hole flowing pressure conditions. Ensuring that the wellhead pressure satisfies Eq. 1 and is not lower than this critical value is a necessary condition for maintaining stable production of a gas well.

2) Critical fluid carrying capacity: In the case of dynamic liquid loading, the key is to calculate the amount of liquid flowing out of the wellhead through Eq. 2 to assess whether the amount of liquid discharged from the wellhead can effectively carry the liquid produced at the bottom of the well. The head can effectively carry the

liquid produced at the bottom of the well. Specifically, it is essential to ensure that the rate of liquid production at the wellhead is greater than or equal to the rate of liquid production at the bottom hole. This balance prevents excessive liquid accumulation at the bottom of the well, which could lead to gas lock and other issues. Achieving and maintaining this critical flow rate is vital for ensuring the efficient operation of the gas well.

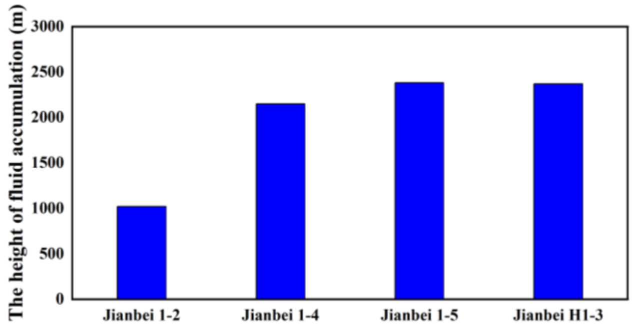

Fig. 1. The height of fluid accumulation in the block

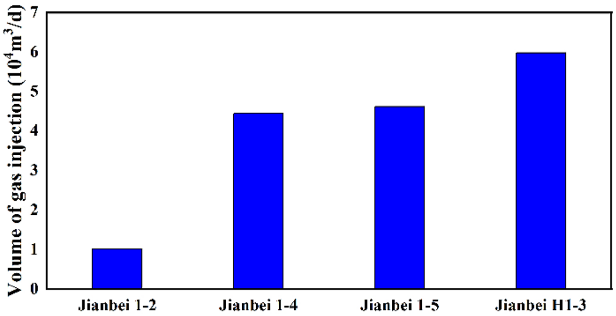

Fig. 2. Gas lift injection volume in the block

In order to optimize the performance of these two aspects, it is necessary to take into account the specific conditions and operating parameters of the gas well, and to take appropriate measures to adjust the bottom-hole flowing pressure and liquid-carrying flow rate, so as to ensure that the gas well can operate in the best condition, at the same time to avoid due to insufficient pressure or carry insufficient fluid caused by production disruption or low efficiency.

$$P_{wf} > P_{tmin} + \Delta P_d \quad (1)$$

$$q_{wout} = A\sqrt{\left(\frac{tmp}{0.22}\right)^4 \frac{\rho_g}{\rho_l}} > q_{win} \quad (2)$$

Style: ΔP_d: Wellbore pressure drop in process, MPa; P_{tmin}: Minimum pressure at wellhead, MPa; P_{wf}: Bottom hole flowing pressure, MPa; q_{wout}: The amount of fluid flowing out of the wellhead, m³; q_{win}: The amount of fluid flowing into the wellhead, m³.

Using 2 MPa as the minimum wellhead pressure, the required bottom-hole flowing pressure for implementing the pressurized gas lift process was calculated for various water and gas production rates. The results are presented in Fig. 3.

The mismatch between the pressurized gas lift process and the basic conditions of the well is one of the key factors limiting its effectiveness. According to the analysis of the applicable limit chart of pressurized gas lift drainage gas production technology (Fig. 4), for some gas wells with too low a bottom hole flowing pressure, the implementation of pressurized gas lift technology has not brought the expected effect of increasing production. The results are shown in Table 3.

Specifically, when the bottom-hole flowing pressure falls below a certain critical value, even the application of pressurized gas lift technology cannot effectively raise the wellhead pressure to maintain normal production levels. This results in a process that is not fully functional and may lead to wasted resources and time due to inappropriate interventions.

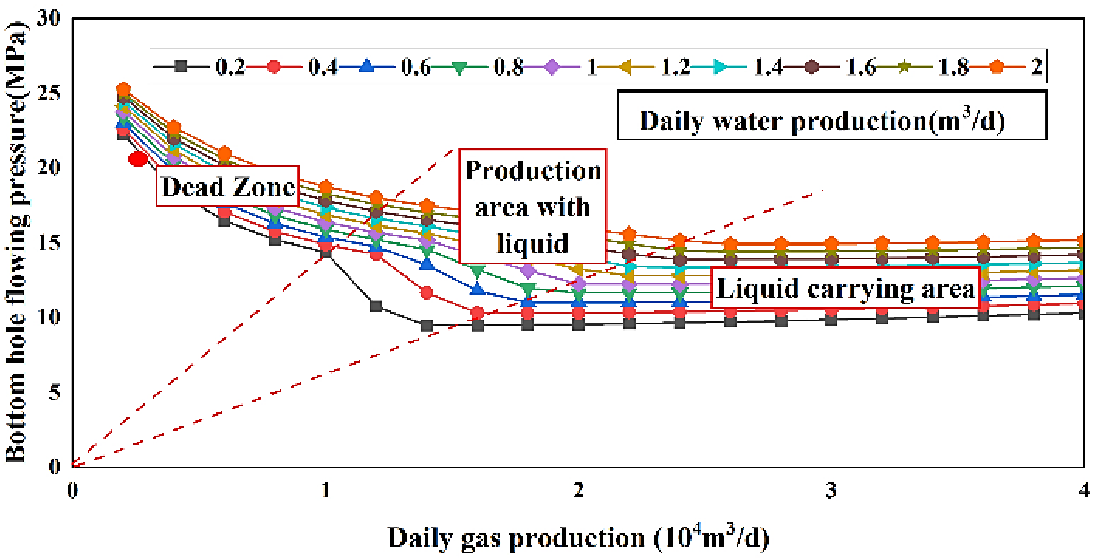

Fig. 3. Booster gas lift adapts to limits

Table 3. Analysis and statistics of the applicability of pressurized gas lift (natural gas)

Well name	Bottom hole flowing pressure(MPa)	Injection pressure(MPa)	Volume of gas injection ($10^4m^3/d$)	Daily gas production ($10^4m^3/d$)	Daily water production (m^3/d)	Applicability evaluation
Jianbei 1-2	10.79	5.8	1.02	0.15	1.52	Not applicable
Jianbei 1-4	20.56	9.01	4.44	0.31	19.07	Applicable
Jianbei 1-5	19.14	8.47	4.62	0.26	12.99	Applicable
Jianbei H1-3	21.74	8.2	5.98	0.2	16.4	Applicable

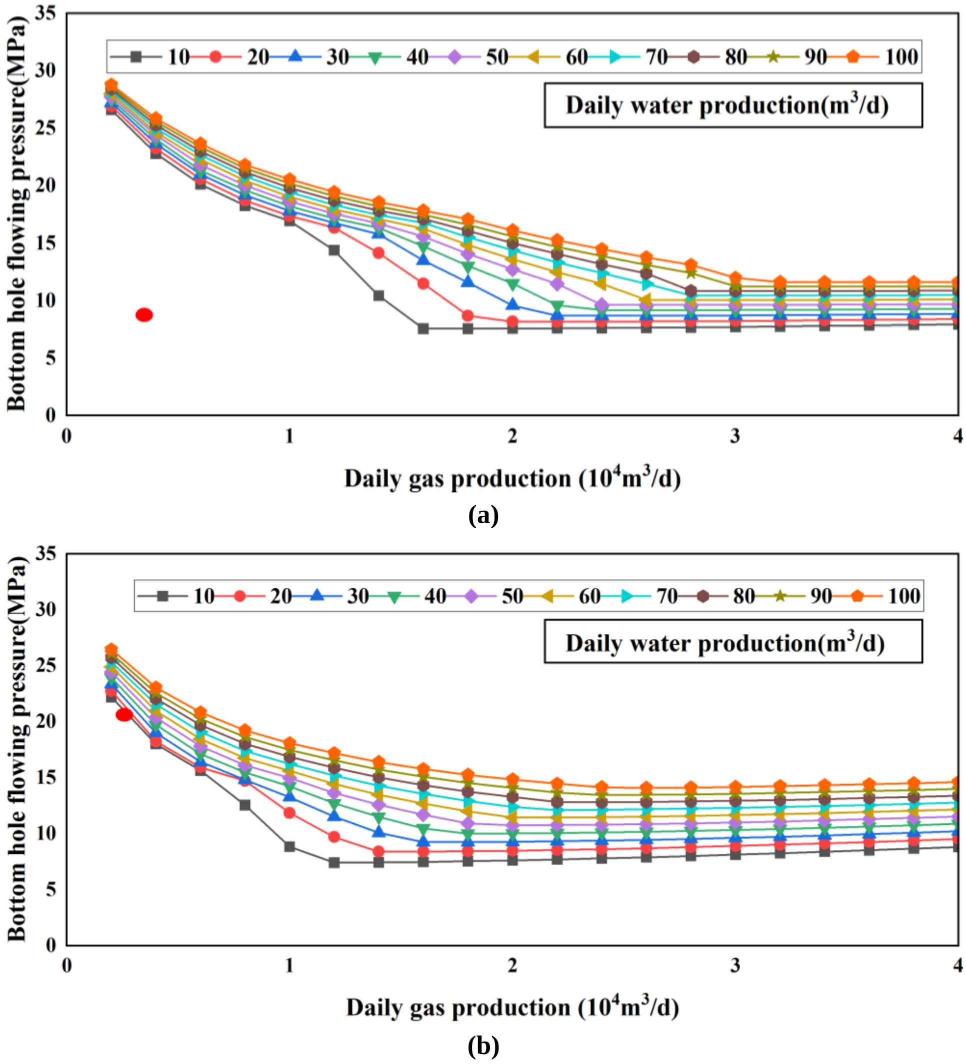

Fig. 4. Gas lift process applicability chart**,** (a) Jianbei 1-2 applicability chart, (b) Jianbei 1-4 applicability chart

(3) Other factors

In addition to the mismatch between the basic conditions of the well and the pressurized gas lift process, the unreasonable tubing size and formation damage are also one of the main factors restricting the effect of the process. The data statistics are shown in Table 4:

1) The unreasonable tubing size: In gas wells with poor stimulation effects, the tubing size is often larger than 73.0 mm (Fig. 5). An excessively large tubing diameter can result in insufficient gas flow velocity to effectively carry liquids, particularly in cases of low gas production. This reduces the efficiency of liquid carryover, thereby impacting the drainage effect and overall well performance.

2) Serious formation damage: the larger skin coefficient of the stratum in the block indicates that the formation damage is serious (Fig. 6). Formation damage increases flow resistance and reduces permeability, which in turn reduces the effective production of gas and liquid, resulting in limited productivity gains even with pressurized gas lifts.

Table 4. Statistics of wellbore structure and skin factor in Jianbei block

Well name	Tubing Diameter(mm)	Tubing down deep(m)	Middle-deep pay zone(m)	Skin factor
Jianbei 1-2	88.9	4278	4713.00	-2.90
Jianbei 1-4	73.0	4250	4667.00	-1343.65
Jianbei 1-5	73.0	4184	4665.00	367.27
Jianbei H1-3	73.0	3790	5031.00	157.39

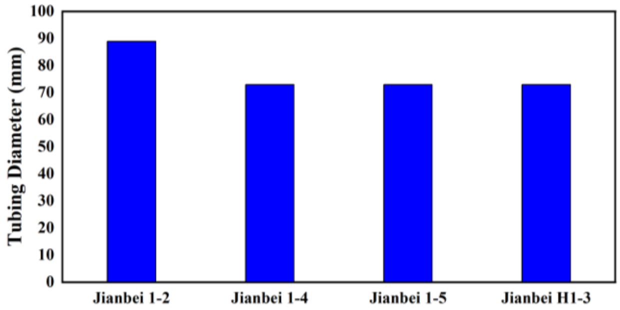

Fig. 5. Size of tubing in Jianbei

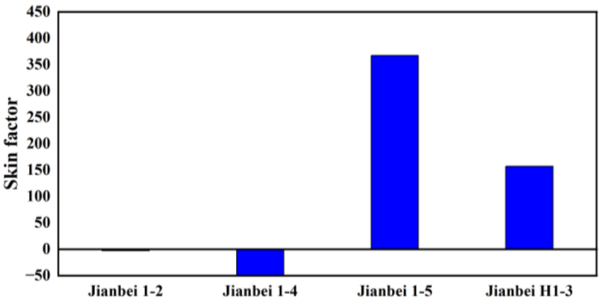

Fig. 6. Coefficient of epidermis in Jianbei

3.3. Tubing size and depth design

Based on the basic principle of optimum diameter selection, the liquid carrying capacity, erosion and pressure loss of oil pipes with different diameters under different pressure, gas production and water production conditions are analyzed, and the optimum diameter is determined, according to the production and pressure conditions of single well, the optimum size of tubing is selected under the condition of fluid carrying and erosion. With the method of simulation, the change of wellhead pressure after tubing run-in is simulated to optimize tubing run-in depth while keeping other parameters unchanged.

1) The optimum drawing method of gas production pipe string size:

Given the gas yield, water yield and pressure, the suitable diameter was selected based on the critical liquid-carrying flow and erosion flow model, and the lowest pressure loss diameter was selected by the multiphase flow model (Fig. 7).

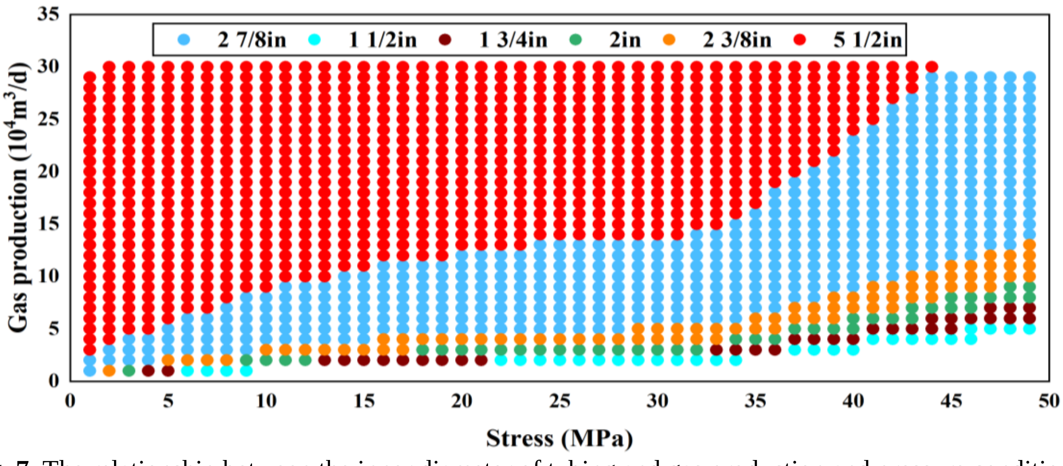

Fig. 7. The relationship between the inner diameter of tubing and gas production and pressure conditions

2) Pressure loss optimization:

Keeping the bottom hole flowing pressure constant, the wellhead pressure at different running depths is calculated according to Eq. 3 [23], and the point with the maximum wellhead pressure is the optimal running depth (Fig. 8).

$$\frac{dP}{dZ} = \rho_m g \sin\theta + \frac{f_m \rho_m v_m^2}{2d} + \rho_m v_m \frac{dv_m}{dZ} \quad (3)$$

Style: dP/dZ: Pressure-gradient force, Pa/m; ρ_m: Density of the mixture, kg/m^3; f_m: Friction coefficient; v_m: Flow rate of mixture, m/s.

Based on this method, the tubing size and tubing run-in depth are optimized according to the production and pressure conditions of each gas-lift well in Jianbei Table 5.

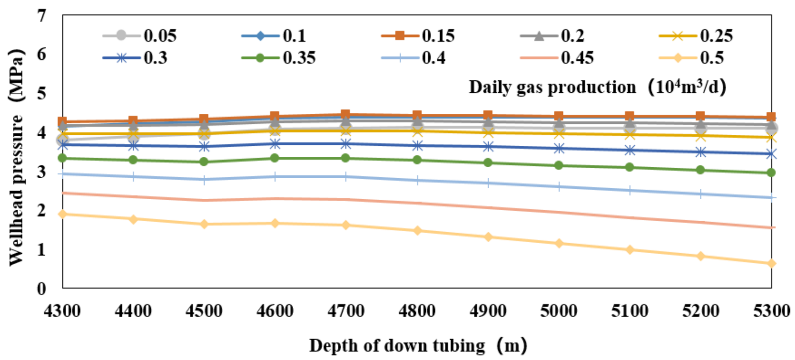

Fig. 8. The relationship between tubing depth and wellhead pressure and gas production

Table 5. Optimization of tubing size and tubing run-in depth of gas lift wells in Jianbei (natural gas)

Well name	Gas production ($10^4m^3/d$)	Volume of gas injection ($10^4m^3/d$)	Injection pressure (MPa)	Bottom hole flowing pressure (MPa)	Inside diameter of present tubing (mm)	Internal diameter of tubing is preferred (mm)	Maximum wellhead pressure (MPa)	Now tubing down depth (m)	Preferred tubing run-in depth (m)
Jian 3	0.24	4.85	6.77	14.45	88.9	73	4.04	4582	4700
Jianbei 1-2	0.15	1.02	5.8	10.79	88.9	60.3	4.44	4278	4700
Jianbei 1-3	0.58	5.11	11.73	30.28	88.9	73	1.91	4582	4300
Jianbei 1-4	0.31	4.44	9.01	20.56	73	73	3.7	4155	4700
Jianbei 1-5	0.26	4.62	8.47	19.14	73	73	4.39	4184	4700
Jianbei 1-7	0.0716	2.78	16.93	33.57	73	60.3	4.11	4613	4800
Jianbei H1-3	0.2	5.98	8.2	21.74	73	73	4.3	3790	4700

3.4. Design of steam injection quantity and pressure

The relationship curve between the gas injection rate and the liquid production rate of gas lift well is called the "Gas lift characteristic curve", which can be obtained by field test. According to the characteristics of the characteristic curve, the left part of the highest point of the curve is fitted into a binomial. Combined with the inflow and outflow curve (Fig. 9), the liquid production and corresponding pressure of the gas lift valve at different depths are calculated by Eq. 4 and Eq. 5 (Fig. 10), optimization of single well gas injection pressure and steam injection rate [24].

$$P_e^2 - P_{wf}^2 = Aq + Bq^2 \quad (4)$$

Style: P_e: Original Formation pressure, MPa; P_{wf}: Bottom hole flowing pressure, MPa; Q: Gas production per well, $10^4m^3/d$; A、B: Constant.

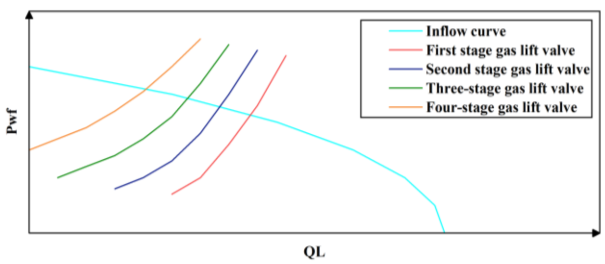

Fig. 9. Typical inflow-outflow curve

$$q_L = Aq_g^2 + Bq_g + C \quad (5)$$

Style: q_L: Liquid production per well, m^3/d; q_g: Gas injection rate of single well, $10^4m^3/d$; A、B、C: Constant.

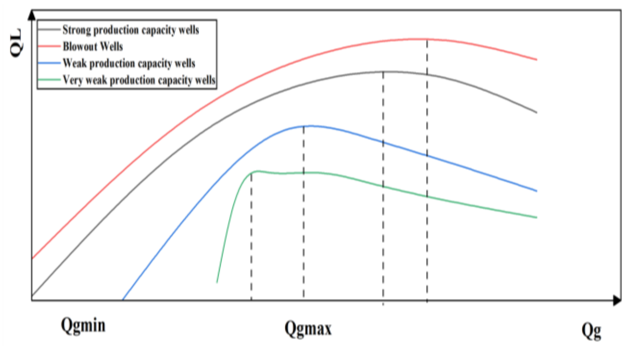

Fig. 10. Typical gas lift characteristic curve

Based on the analysis of inflow-outflow curve and gas lift characteristic curve of single well, the gas injection pressure and gas injection rate of gas lift valves at different depths under the condition of current tubing size are calculated, so as to optimize the gas injection pressure and gas injection rate of each well, the results are shown in Table 6.

Table 6. Gas injection pressure and gas injection rate optimization of gas lift wells in Jianbei (natural gas)

Well name	First stage gas lift valve			Second stage gas lift valve			Three-stage gas lift valve			Four-stage gas lift valve		
	Depth (m)	Volume of gas injection ($10^4m^3/d$)	Injection pressure (MPa)	Depth (m)	Volume of gas injection ($10^4m^3/d$)	Injection pressure (MPa)	Depth (m)	Volume of gas injection ($10^4m^3/d$)	Injection pressure (MPa)	Depth (m)	Volume of gas injection ($10^4m^3/d$)	Injection pressure (MPa)
Jian 3	1000	0.02	0.66	2000	0.51	3.12	3000	1.10	9.76	4000	2.16	20.51
Jianbei 1-2	1000	0.11	0.19	2000	0.48	1.39	3000	1.04	5.15	4000	1.92	10.55
Jianbei 1-3	1000	/	/	2000	0.21	2.16	3000	1.60	7.21	4000	3.11	15.12
Jianbei 1-4	1000	0.41	0.94	2000	1.39	7.13	3000	2.30	17.88	4000	3.25	29.17
Jianbei 1-5	1761	1.46	3.92	2655	2.59	10.39	2997	3.04	13.24	3047	3.12	14.01
Jianbei 1-7	1694	0.68	1.81	2572	1.41	4.70	3257	2.16	9.82	3687	3.17	14.04
Jianbei H1-3	1780	0.08	1.48	2609	1.11	4.05	3356	2.11	7.84	4000	3.42	11.76

3.5. Optimization of gas lift technology in the Jianbei gas reservoir

In view of the main problems that affect the effect of pressurized gas lift technology in the Jianbei block, such as reservoir pollution, unreasonable tubing size and serious fluid accumulation, we can make specific optimization schemes respectively, and the gas injection pressure and gas injection quantity of each single well are optimized:

1) Fluid accumulation problem: Excessive fluid accumulation in the wellbore may lead to gas lock phenomenon, reduce well productivity and increase energy consumption. The amount and pressure of gas injection can be adjusted according to well conditions to ensure that gas can effectively carry the liquid, at the same time to avoid the energy waste caused by excessive gas injection or consider combining with other efficient drainage methods, such as coiled tubing drainage, electric submersible pump, etc.

2) Unreasonable tubing size: the tubing size of some gas wells is too large (larger than 73.0 mm), which results in insufficient gas flow velocity to carry liquid effectively and affects the effect of fluid discharge, according to the specific production parameters (gas production, water production, pressure, etc.) of each gas well, through calculation and simulation, the most suitable tubing size can be selected to ensure that the gas can carry the liquid at the best flow rate, according to the real-time monitoring data, the tubing size can be adjusted flexibly to meet the production demand in different stages.

3) Reservoir pollution: the reservoir pollution increases the flow resistance and reduces the permeability, which results in the pressure boosting gas lift even if implemented, production capacity is also limited and it is recommended that appropriate formation remediation techniques, such as acidizing, hydraulic fracturing or chemical cleaning, be selected to restore formation permeability, and that pollution prevention measures be applied in subsequent operations.

4) Gas lift parameter optimization: Based on the above three adjustments, customize the gas injection pressure and gas injection volume plan for each well, ensure that every gas well can be operated under optimal conditions, establish a long-term monitoring mechanism, dynamically adjust injection parameters according to actual production data to ensure continuous optimization.

4- Conclusions

In the comprehensive evaluation and optimization of pressurized gas lift technology applied to the Jianbei gas reservoir, we conducted an in-depth analysis focusing on the principal restrictive factors affecting its efficiency. Our efforts led to the implementation of precise optimization measures designed to enhance the operational effectiveness of this technology. Key actions included re-evaluating and selecting optimal tubing sizes and depths, as well as meticulously adjusting gas injection volumes and pressures. These strategies not only addressed existing technical challenges but also laid a robust scientific foundation and provided essential technical support for future reservoir management and development, ensuring optimal conditions for gas well operations.

Our conclusions are summarized as follows:

1) Through the comprehensive evaluation of pressurized gas lift technology in the bedrock gas reservoir of northern Jianbei, we have identified the main restricting factors as follows: tubing size mismatch, severe fluid accumulation, significant formation pollution, and unreasonable process parameter design. Based on these findings, we have developed corresponding adjustment countermeasures and upgrading plans for each well. These measures aim to optimize tubing dimensions, address fluid accumulation issues, remediate formation pollution, and refine process parameters. Based on these findings, corresponding adjustment countermeasures and upgrading schemes are formulated for each well to ensure that each well can operate according to the relatively optimal conditions given by the scheme.

2) According to the principle of diameter optimization, each single well in Jianbei block was re evaluated and the most suitable tubing size was selected as 60.3~73.0mm, and the best depth was 4300~4700m, so as to ensure that the gas can carry liquid at the best flow rate and improve the liquid carrying efficiency.

3) Based on the gas lift characteristic curve, combined with the specific conditions of each gas well, the gas injection volume of 1~3×$10^4 m^3$/d and the gas injection pressure of 5~18MPa were redesigned to ensure that the gas recovery rate and recovery rate were maximized while meeting the liquid carrying requirements.

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Compliance with Ethical Standards Section

• Disclosure of potential conflicts of interest: There are no conflicts of interest.

• Research involving Human Participants and/or Animals: Not applicable.

• Informed consent: There is informed consent in publishing this research.

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بحث وتطبيق تكنلوجيا رفع الغاز في خزانات الغاز الصخرية – دراسة حالة لخزان الغاز جينابي

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الخلاصة

يعد خزان غاز جينابي , الواقع في جبال التون في حوض قايدام , بمثابة خزان غاز نموذجي. منذ تشغيلها واجهت ابار الغاز بشكل عام اختراقا مائيا , مما ادى الى اننخفاض كبير في الانتاج . ولمعالجة هذه المشكلة تم تنفيذ عملية رفع الغاز المضغوط لتصريف المياه وتعزيز الانتاج . وقد اظهرت معظم الابار زيادات ايجابية في الانتاج , فقط اظهر بعضها تغييرا طفيفا او معدوما في الانتاجية بعد المعالجة . لذلك من الضروري التحقق في اسباب هذه التناضات وتعديل / تطوير الخطة الاصلية وفقا لذلك . من خلال التحليل الشامل من وجهات نظر مختلفة بما في ذلك مشكلات تراكم السوائل وعملية رفع الغاز نفسها , وبنية حفرة البئر, تم تحديد ان العوامل الاساسية التي تحد من فعالية رفع الغاز في خزان غاز جيانبي هي تراكم السوائل الشديد في حفرة البئر, وضعف القدرة على التكيف لعملية رفع الغاز في بعض الابار, وحجم الانابيب غير المناسب, والضرر الشديد للتكوين . ولمعالجة هذه المشكلات تمت ترقية خطة رفع الغاز لخزان الغاز جينابي وتحسينها . تم اعادة تصميم المعاملات المناسبة بناءا على مبادىء تحسين قطر الانابيب والمنحنيات المميزة لرفع الغاز بهدف تعظيم تاثير التحفيز لرفع الغاز . يعمل هذا النهج على حل التحديات التقنية الحالية بشكل فعال ويوفر اساسا علميا متينا ودعما فنيا لادارة وتطوير مكامن الغاز في المستقبل مما يضمن التشغيل الامثل لابار الغاز .

الكلمات الدالة: حجر الاساس، رفع الغاز، العوامل المقيدة، استعادة الغاز عن طريق تصريف المياه.