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Optimization of Anti-freezing and Unblocking Measures for Natural Gas Wells and Pipelines: A Case from the Gaoqiao Area of Jingbian Gas Field, Ordos Basin

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Abstract

During winter production, new wells in the Gaoqiao area are concentrated in production, with high output, long single-well pipelines, high surface gathering and transportation pressure, and crisscrossing terrain. These conditions cause gas wells to be prone to freezing and blocking in winter, which significantly restricts gas well production. It is urgent to conduct research on anti-freezing and blocking measures at the wellhead. Starting from the current production situation in winter, this paper comprehensively sorts and categorizes key wells and those that are prone to freezing and blockage. The classification and frequency of freezing and blockage are statistically analyzed, and the reasons for freezing and blockage are studied. Solutions are analyzed for each situation, and overall, the impact of freezing and blockage on production is significantly reduced, fully ensuring the production capacity of gas wells in winter.

Keywords

Gas well, Anti-freeze blockage, Measures for unblocking, Gaoqiao area, Jingbian Gas Field

Introduction

The surface gathering and transportation mode in Gaoqiao area has undergone three stages of transformation, evolving into the current medium and low-pressure gas gathering mode (without alcohol injection pipelines) and station boosting mode. After entering winter production, due to factors such as high production, high pipeline pressure, large water production, and no alcohol injection pipelines, as well as the lack of alcohol injection pipelines in new wells, the pipeline is prone to freezing and blockage in winter, limiting the production of gas wells. The lowest wellhead temperature during winter production in the region is only around 0.5℃, with an average ambient temperature of around -18℃. The produced water in the pipeline is prone to forming hydrates under the interaction of low temperature and high pressure, resulting in gas gathering pipeline freezing and blockage, which seriously affects winter production.

After the pressurization renovation of the gas gathering station area in Gaoqiao area of the Jingbian gas field, although the overall regional pressure has decreased, there are still varying degrees of freezing and blockage in the gas production pipeline during winter operation, which greatly affects the effective production capacity of the gas well. The freezing blockage of natural gas Wells mainly occurs in surface pipelines, wellhead gas production trees, and pipelines near flowmeters. At the same time, the mobile alcohol injection vehicles at the wellhead are generally affected by various unfavorable factors such as natural gas and road conditions, making it difficult to ensure the stable operation of the winter gas well for a long time. On the basis of previous achievements, further analysis and research of anti-freezing and unblocking measures for gas wells are carried out, and

corresponding implementation suggestions are put forward. This paper first classifies the freezing and blocking situation of gas wells, counts the frequency of freezing and blocking, analyzes the influencing factors, conducts a detailed study on the causes of freezing and blocking, and proposes corresponding solutions.

1. Geological setting

Ordos Basin is a large sedimentary basin with multicycle evolution and multiple sedimentary types, with an area of about 25×10^4 km^2 (Figure 1a) [1-3]. In view of the present structure and evolution history, the regional structure can be divided into six first-order structural units: Western edge thrust belt, Tianhuan sag, Yishan slope, Jinxi folding belt, Yimeng uplift and Weibei uplift (Figure 1b) [4-6].

Gaoqiao area is mainly located in the central part of the Northern Shaanxi Slope Belt of Ordos Basin. It has a relatively gentle structural belt. The average slope rate of the monocline trending to the west is 3-5m/km, with a total area of about 6300 km^2 [2, 7, 8]. In recent years, more than 400 gas wells of various types have been drilled in the Gaoqiao area. The proven reserves of the area exceed 12 billion cubic meters and the predicted reserves exceed 150 billion cubic meters.

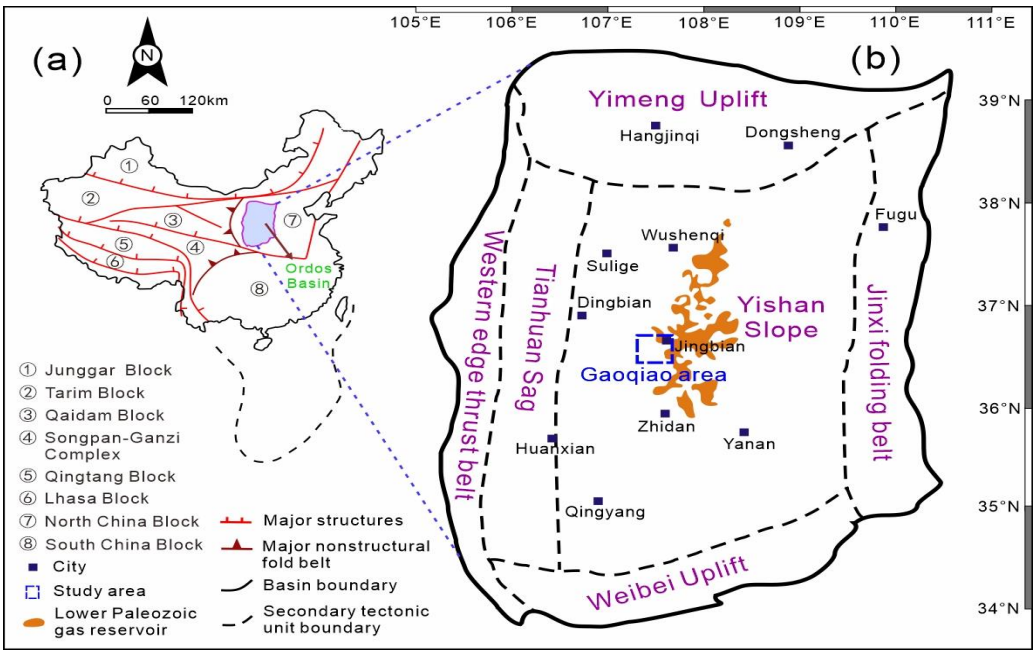

Figure 1. The geographical location of the Gaoqiao area of Jingbian Gas Field.

2. Classification of freezing and blockage situations

Winter production pipelines are prone to freezing and blockage, resulting in ineffective production capacity of gas wells. In the winter of 2022 and 2023, there were 28 well groups prone to freezing and blockage, affecting 75 gas wells with a daily impact of 510000 cubic meters of gas. The main manifestations of freeze blockage are ground pipeline freeze blockage, wellhead freeze blockage, and station pipeline freeze blockage (Tabe 1).

Table 1. Classification table of freezing type

Freezing blockage situation	Frozen blockage location
Ground pipeline freeze blockage	Connecting branch pipe sections in series
	Connecting the main pipeline section in series
	Upstream and downstream of wellhead needle valve
wellhead freeze blockage	New well tubing
	Wellhead equipment
station pipeline freeze blockage	At the bend of the ground pipeline in the distribution needle valve or station area

3. Frequency and influencing factors of freezing blockage

Analyzing production data from December 2023 to March 2024, it was found that the frequency and affected gas volume of frozen blockages in connecting main pipes and connecting branch pipes were much higher than other types of frozen blockages, which were the main influencing factors for winter production of gas wells and pipelines (Figures 2 and 3).

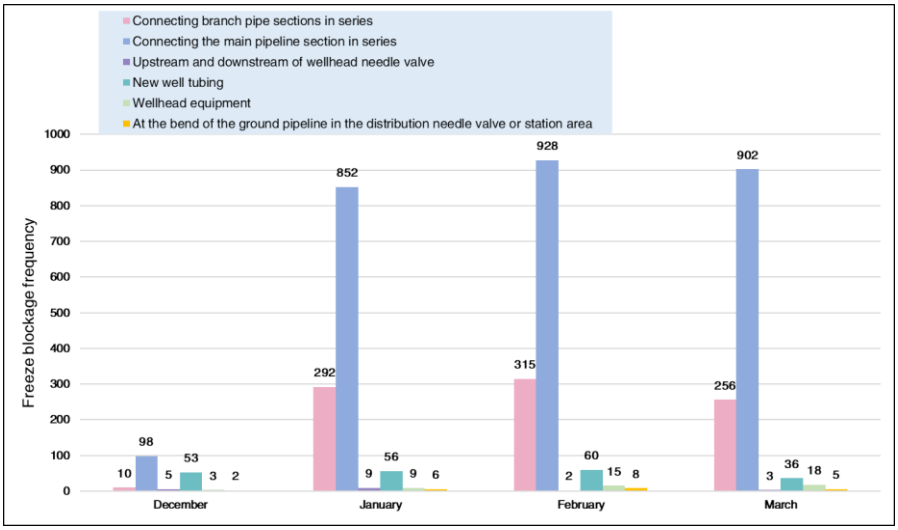

Figure 2. Statistical chart of frozen blockage frequency.

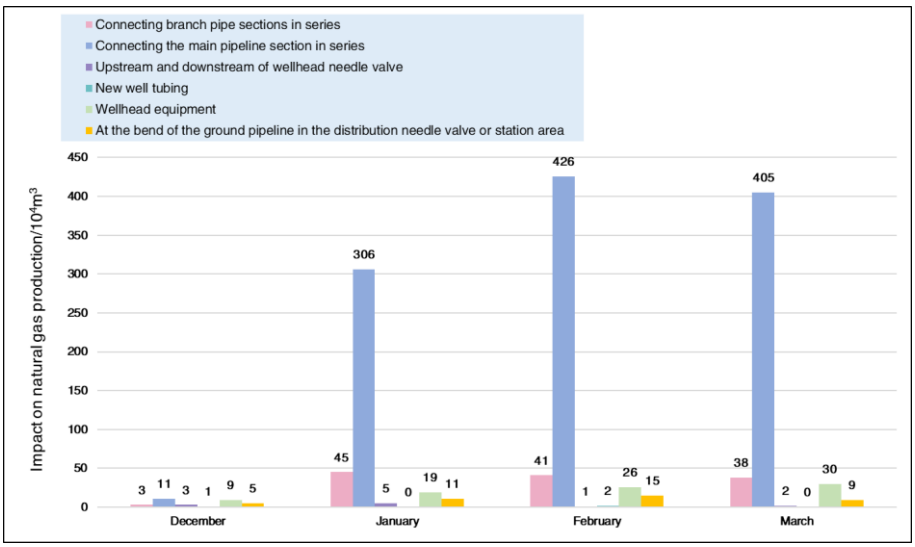

Figure 3. Statistical chart of the impact of natural gas production.

4. Analysis of causes of freezing blockage

4.1 No alcohol injection pipeline for some wells

The gas wells and some booster stations that were put into operation in 2023 and 2024 do not have alcohol injection pipelines, making it impossible to achieve continuous alcohol injection, resulting in frequent freezing and blockage of some gas well pipelines with high water production or large pipeline elevation differences. After the whole area is pressurized, the chance of freezing in the gas well of no alcohol injection pipeline will be greatly reduced. Mobile alcohol injection or end-point alcohol injection in some key gas wells and timely adjustment of the system and mode during operation can better prevent freezing.

4.2 Unable to simultaneously inject alcohol between connected wells

Part of the connected well groups cannot achieve continuous alcohol injection at each endpoint simultaneously. When a gas well

at a certain endpoint produces liquid or has a high production rate, it is prone to branch pipe freezing and blockage. By optimizing the group of alcohol-injection wells and adjusting the pipeline of alcohol-injection, the frequency of freezing and the influence of natural gas volume can be reduced.

4.3 High operating pressure of well group pipeline network

Owing to the large number of connected wells and the high production capacity of individual wells, some of the series connections result in high operating pressure in the pipeline network, leading to a high frequency of freezing and blockage during winter operation of gas wells. In particular, the high production pressure of newly put-into-production gas Wells can easily lead to freezing.

4.4 Exposed pipelines with insufficient burial depth

Due to the deep mountain valleys, some gas wells are difficult to fully detect during drone patrols, and pipeline management is not thorough, resulting in frequent pipeline freezing and blockage in winter. Regular pipeline patrol and timely treatment of exposed pipelines can prevent gas well pipeline freezing to a certain extent.

4.5 Throttling of gas well flowmeter

Orifice flow meters and wedge-shaped flow meters have throttling elements, which can easily cause throttling when there is a large amount of upstream gas or high pressure, leading to pipeline freezing and blockage. In winter production, the flowmeter can be temporarily replaced with a nipple to reduce the throttle pressure and production pressure difference and improve the pipeline transmission capacity.

4.6 Pneumatic diaphragm valve instrument air pipeline frozen and blocked

When there is liquid water or corrosion inhibitor in the instrument air pipeline of the pneumatic diaphragm valve, it is easy to cause freezing and blockage of the instrument air pipeline, resulting in the inability of the diaphragm valve to open. During the gas well patrol, the instrument gas source is purged and the remote switchgear is adjusted to reduce the failure rate. At the same time, the plunger gas well disposal efficiency is effectively improved through the management mechanism of daily plunger fault investigation, real-time tracking of disposal progress, and collaborative processing of difficult faults.

5. Solution measures

5.1 Optimize the string connection method of well groups and reduce pipe pressure

By optimizing the series connection mode of the G1-1 well group at the GaoX1 station and G2-1 well group at the Gao-X2 station (Figure 4), the operating pressure of the pipeline network is reduced and the frequency of well group freezing and blockage is reduced. At present, the above well groups operate smoothly in winter. After optimization, the pipe network pressure and freezing frequency are significantly reduced. In 2024, it is planned to optimize the surface pipelines of 7 well groups, which is expected to release 8×10^4 cubic meters of natural gas per day and reduce the amount of natural gas affected by freezing blockage by 105×10^4 cubic meters.

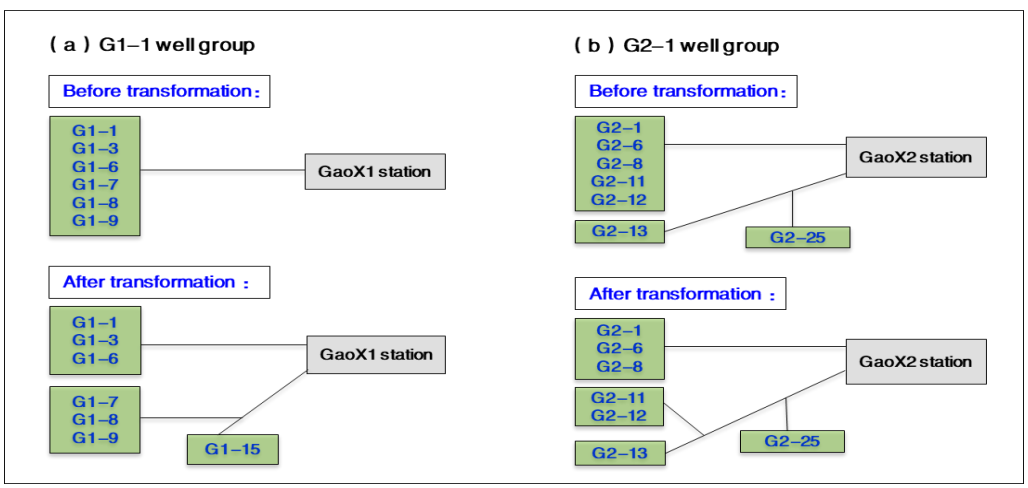

Figure 4. Gas gathering process transformation of G1-1 (a) and G2-1 (b) well group.

5.2 Optimize well group alcohol production line

Adjust the alcohol injection process for the G1-25 and G1-33 main pipes at the Gao X1 station to achieve simultaneous alcohol injection in the winter for two high-yield well groups on this main pipe (Figure 5). At present, both well groups are operating normally. After the optimization of the alcohol injection pipeline, the gas well basically does not freeze up, and the natural gas volume is obviously increased. In 2024, it is planned to optimize the alcohol injection pipelines of 5 well groups, and it is expected to reduce the natural gas volume affected by freezing blockage by 13×10^4 cubic meters.

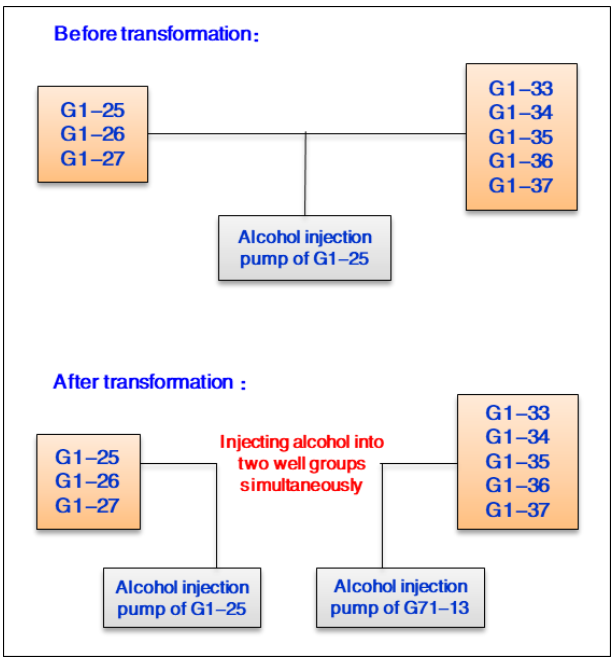

Figure 5. Revamp of alcohol injection process of G1-25 well group.

5.3 Optimize the mobile alcohol injection method

Gas wells with good oil sleeve connectivity are selected for the well group, and casing injection of alcohol is adopted. For wells with poor oil sleeve connectivity, multiple surface injections of alcohol are adopted. By optimizing the mobile alcohol injection method, the freezing and plugging frequency of 8 easily blocked well groups in winter was reduced by 36 times. In 2024, it is planned to carry out pre-injection of alcohol in advance for good groups with good connectivity and high operating pressure in the winter production stage through the summer production regularity of gas wells to prevent freezing of surface pipelines.

5.4 Pipeline governance

Management of hidden dangers in old well pipelines: a comprehensive survey of pipeline burial depth will be conducted for gas wells that are prone to freezing and blockage, and insulation cotton and blankets will be added to exposed areas.

Acceptance of buried depth and ball passing of new well pipelines: communicate closely with the construction party, assign a dedicated person to be responsible, strengthen the acceptance of buried depth and ball passing before the new well pipeline is put into operation, and ensure the normal operation of the new well pipeline in winter. The buried depth of the new well pipeline is disclosed in the whole process, and all data statistics are complete to ensure that all new pipelines are not exposed.

5.5 Optimize intermittent well production system

During winter operation, extend the interval well opening time, shorten the well closing time, and reduce pipeline pressure fluctuations and operating pressure. For gas wells that are prone to blockage, the method of daytime production and nighttime well closure is adopted to reduce the frequency of freezing and blockage.

Stages 1 and 2 are intelligent optimization of production (Figure 6). After the adjustment of the system, the pressure difference of the oil sleeve has significantly decreased, but the degree of recovery is still insufficient, and the shutdown time will continue to be extended. The production system of Stage Three is to open for 3 hours and close for 15 hours, with a daily gas production of 3600 cubic meters. The production system of Stage 4 has been adjusted to open for 3 hours and close for 21 hours. The degree

of oil pressure recovery is high, and the daily gas production has been increased to 4500 cubic meters without obvious freezing and blockage. Winter production should be carried out as much as possible during the day to prevent freezing and blockage of gas wells caused by low temperatures at night.

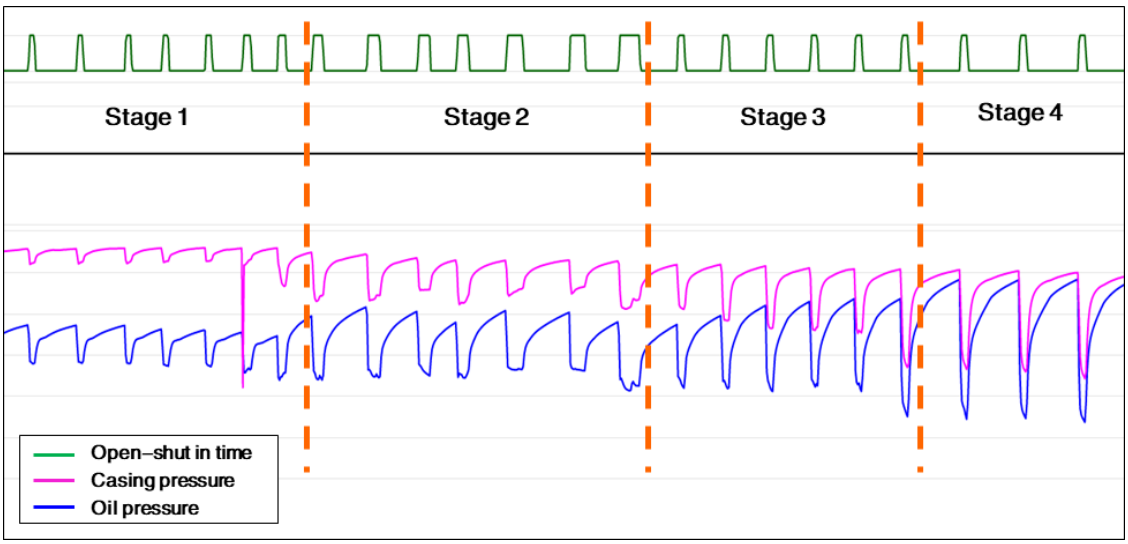

Figure 6. System optimization of G1-33 well.

5.6 Strengthen the management of station electric heat tracing

Strengthen the management of electric heat tracing and insulation for key equipment such as liquid accumulation bags and sewage pipelines in important areas of the station. At the same time, install electric heat tracing for high-yield well group pipelines in the incoming area to prevent freezing and blockage inside the gas well station. The pipeline in the gas collecting station can also be operated by the alcohol injection pump with a lower stroke in the station to prevent freezing.

6. Conclusion

Through statistical analysis of well logs that are prone to blockage, handling issues such as burial depth and foreign object blockage in pipelines, implementing proactive measures such as pre-injection of alcohol and adjusting compressor parameters to prevent freezing and blockage, the occurrence of pipeline freezing and blockage in some gas wells at the gas gathering station has significantly decreased, with a 17.5% decrease in frequency compared to the same period last year, and a daily decrease of 13×10^4 cubic meter in production impact. In the later stage, research on anti-freezing and unblocking measures for gas wells will continue to be carried out to ensure the full production capacity of gas wells in winter.

References

[1] Yang J. The discovery of lower Paleozoic natural gas in Shanganning Basin [J]. Natural Gas Industry, 1991, 11(2):1-6.

[2] Luo X, Tian J, Zhang J, et al. Reservoir characteristics of Ma 5_(1+2) sub-member of the Ordovician Majiagou Formation in Gaoqiao Area, Ordos Basin [J]. Lithologic Reservoirs, 2012, 24(4): 24-28.

[3] Jiang F, Chengzao J I A, Xiongqi P, et al. Upper Paleozoic total petroleum system and geological model of natural gas enrichment in Ordos Basin, NW China [J]. Petroleum Exploration and Development, 2023, 50(2): 281-292.

[4] Min Q, Yang H, Fu J. Deep basin gas in Ordos Basin [J]. Natural Gas Industry, 2000, 20(6):11-15.

[5] Han W, Tao S, Huang S, et al. Carbon isotope reversal and its relationship with natural gas origins in the Jingbian gas field, Ordos Basin, China [J]. International Journal of Coal Geology, 2018, 196:260-273.

[6] Xin X, Liu L, Li X, et al. Sequence stratigraphy, sedimentary characteristics of barrier coastal sedimentary system of the Benxi Formation (Gaoqiao area, Ordos basin) and favorable reservoir distribution-ScienceDirect [J]. Energy Reports, 2021, 7:5316-5329.

[7] Chen D, Zhu Y, Wang W, et al. Pore structure of tight sandstones with differing permeability: The He 8 Member of the Middle Permian Lower Shihezi Formation, Gaoqiao area, Ordos Basin [J]. Energy Science and Engineering, 2024, 12(1): 117-135.

[8] Liu S, Li J, Jin F, et al. Genesis of efficient reservoirs in mixed sedimentary setting: a case study of Benxi Formation in the Gaoqiao area, Ordos Basin [J]. Turkish Journal of Earth Sciences, 2024, 33(2): 118-145.