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Methods and Effect Analysis of High Water-Producing Gas Well Treatment in Jin A Well Block of Dongsheng Gas Field

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Abstract

Jin A Well Block is the highest liquid-gas ratio in Dongsheng Gas Field. In recent years, with the gas field entering the middle and late stage of development, the number of high-water-content gas well has increased significantly. To restore and enhance the productivity of high-water-content gas well, the demonstration process of high water production measures and the selection of drainage production process types have become extremely important parts of the production resumption process. This paper elaborates on the demonstration basis and process of high-water-content gas well measures in Jin A Well Block, and analyzes the effects of mechanical drainage measure wells in 2025, so as to obtain the most suitable measure type for this well block. It provides a basis for the well selection in the demonstration of measure wells in this block in the future, and also offers a reference for the production resumption of high-water-content gas well in other high water production gas fields.

Keywords

Measure Well; Dongsheng Gas Field; High Water Production; Mechanical Drainage.

1. Introduction

Dongsheng Gas Field is located in the northern part of the Yishan Slope in the Ordos Basin, and its reservoir type is a typical high-water-cut-tight gas reservoir. Jin A Well Block is situated in the braided river development area on the southwestern margin of Dongsheng Gas Field, with the development intervals being the Lower Shihezi Formation and Shanxi Formation of the Lower Permian in the Upper Paleozoic. As a typical low-pressure and high water saturation area in Dongsheng Gas Field, the average water-gas ratio here can reach 9.0 $m^3/10^4m^3$. In recent years, with the development of Dongsheng Gas Field entering a new phase (2021 to the present), the development area has gradually shifted to high-water-comtent area, resulting in a large number of liquid loading wells and high-water-content gas well. Conventional foam drainage assisted with negative pressure gas production often proves ineffective in sufficiently unloading liquids to restore well productivity. This limitation also hinders the reactivation of water-flooded gas wells, thereby severely constraining the efficient development of gas reserves. In 2025, there are 13 High Water-Cut Well in Jin A Well Block. To realize the stable resumption of production of high-water-content gas well, the selection and tracking of their treatment methods are extremely important. For different high-water-content gas well in Jin A Well Block, it is particularly crucial to analyze the fracturing, gas testing, drilling encounter, logging, production, downhole string conditions and different water-gas ratios of gas wells, evaluate their potential, predict geological reserves, conduct measure demonstration, and select appropriate measure methods to resume production of high-water-content gas well.[1]

To achieve the rapid production resumption of high-water-content gas well in Jin A Well Block, shorten the effect cycle and reduce production costs, Dongsheng Gas Field has attempted to apply different measure methods for treatment. Through the application of a series of preliminary measures, the optimal treatment countermeasures for different types of high-water-content gas well in this block and the application boundary conditions of different mechanical production process wells have been explored. Different from previous understandings, determining the selection of mechanical production processes by liquid production has limitations, and the production resumption effect is often not ideal when the selection of mechanical production processes is only decided by liquid production. This paper describes the measure principles of Jin A Well Block and analyzes several single wells using different measure methods, providing technical support for the treatment methods of High Water-Cut Well in the next step, and also a reference for the treatment of High Water-Cut Well under similar engineering and geological conditions.[2]

2. Regional Geological Setting

Jin A Well Block is located in the northern margin of the Ordos Basin with the development intervals being the Lower Shihezi Formation (P_1x) and Shanxi Formation (P_1s) of the Lower Permian in the Upper Paleozoic. The main gas-producing intervals are the He 8 Member of the Lower Shihezi Formation and the Shan 1 Member of the Shanxi Formation, with a formation thickness of 150-220m. The reservoir lithology is mainly lithic sandstone and quartz sandstone, with moderately to well sorted clastic particles. The cementation types are dominated by illite cementation and siliceous cementation, with a strong cementation degree.

The overall physical properties of the reservoir are poor: the porosity is 5-10% with an average of 7.2%; the permeability is 0.01-0.1 mD with an average of 0.05 mD, belonging to an ultra-low permeability tight reservoir. The pore types are mainly intergranular pores and intragranular dissolved pores, with a pore throat radius of 0.05-0.2 μm and poor connectivity. The reservoir burial depth is 2800-3700 m with an average of 3250 m, the formation temperature is 100-120 °C, the original formation pressure is 32-38 MPa, and the pressure coefficient is 0.75-0.90, belonging to a low-pressure gas reservoir.[3]

3. Types of Treatment Measures for High Water Production Gas Wells

A total of 13 well times of High Water-Cut Well measure operations were implemented in Jin A Well Block in 2025, mainly including three types of mechanical drainage wells: pumping unit, jet pump and electric submersible pump (ESP). These three types of drainage equipment are applied to high water production gas wells under different boundary conditions. Based on previous studies on the principle characteristics, liquid discharge capacity and running depth of different mechanical drainage processes, the application boundaries of mechanical drainage processes in Dongsheng Gas Field are clarified, and the selection of single well treatment types is determined in combination with field application conditions.

In the pumping unit drainage gas recovery process, the liquid discharge capacity has a significant positive correlation with the pump volume, and the polished rod load of the pumping unit changes regularly with the increase of pump running depth and liquid discharge rate. It is necessary to carry out targeted load analysis combined with different combinations of running depth and discharge rate. The gas wells selected for pumping units in Jin 30 Well Block are mainly those with a daily liquid production of less than $20m^3$.

The liquid discharge efficiency of the jet pump process is mainly controlled by the bottom hole flowing pressure, and the two show a positive correlation law: when the designed liquid discharge capacity is 50 m^3/d, the bottom hole flowing pressure needs to be maintained at 15-18 MPa; when the liquid discharge capacity is increased to 100 m^3/d, the required bottom hole flowing pressure is correspondingly increased to 19-25MPa. The gas wells selected for jet pumps in Jin 30 Well Block are mainly those with a daily liquid production of $20\text{-}50m^3$.

The performance parameters of the ESP process follow a clear correlation mechanism: the lift is proportional to the number of impeller-diffuser stages, and the discharge rate is positively correlated with the ESP speed. The currently applied ESP equipment in the field can fully cover the liquid discharge requirements of gas wells within 3500m and with a daily liquid production of less than 200m³ in Dongsheng Gas Field. This process is mainly used for gas wells with a daily liquid production of 50-100m³ in Jin 30 Well Block.[4]

4. Demonstration and Analysis Process of High Water-Cut Gas Well Treatment

4.1 Analysis of Single Well Geological Potential

Single well geological potential is the premise and foundation for the implementation of measures in high-water-production gas wells, and the core is to clarify the support degree of reservoir geological conditions for gas production capacity and the potential tapping space. First of all, based on the structural background and reservoir sedimentary characteristics of the well block, key parameters such as the thickness, porosity, permeability and gas saturation of the reservoir drilled by a single well are determined through logging interpretation and seismic data inversion, so as to judge whether the reservoir has the material basis for high production potential. Secondly, combined with the single well gas testing data, the reservoir boundary conditions, permeability anisotropy and formation damage degree are analyzed through the pressure build-up curve, and the controlled reserves and recoverable reserves of the single well are calculated. At the same time, by comparing the production performance and geological characteristics of adjacent wells, the geological advantages and differences of the single well in the block are analyzed, the matching relationship between the current production and geological potential is clarified, and the problems of insufficient potential release caused by reservoir heterogeneity, formation damage or unreasonable development methods are identified, providing a geological basis for the formulation of subsequent measures.[5]

4.2 Determination of Gas Well Life Cycle Stage

The gas well life cycle includes five stages: well construction period, initial production period, stable production period, decline period and abandonment period. The production characteristics, main contradictions and measure requirements of different stages are significantly different. Accurate determination of the life cycle stage of a single well is the key to the effectiveness of measures. Based on the dynamic change laws of single well production data (daily gas production, daily water production, wellhead pressure, bottom hole pressure, gas-water ratio, etc.), combined with production decline curve analysis, bottom hole pressure build-up test and other methods, the life cycle stage division is carried out. The initial production period focuses on the law of productivity release to judge whether there are problems such as rapid water breakthrough and productivity fluctuation in the reservoir; the stable production period corely analyzes the production stability and gas-water ratio change trend to evaluate the reservoir energy supply capacity; the decline period focuses on the production decline rate and water cut rising law to clarify the dominant factors of decline (such as reservoir energy depletion, water lock damage, gas coning effect, etc.). Through the determination of the life cycle stage, the main contradictions of the current single well are clarified, for example, the bottom hole liquid loading problem that may be faced by gas wells in the stable production period, and the reservoir damage or energy shortage problem that may exist in gas wells in the decline period, providing targeted guidance for the selection of treatment directions.

4.3 Wellbore Integrity Evaluation

Wellbore integrity is the safety guarantee for the implementation of measures in high water production gas wells, which is directly related to the feasibility, safety and long-term effect of measure construction. Based on gas well completion data, pressure monitoring data during production, new well operation and workover operation records, a comprehensive evaluation is carried out from the aspects of casing strength, cement sheath cementing quality, wellhead device tightness and downhole tool working conditions. The tubing integrity and annulus smoothness are judged through the previous gas lift. Technical means such as casing stress calculation, cement sheath bonding quality logging interpretation and wellhead pressure leakage test are adopted to detect whether the casing has defects such as corrosion, deformation and fracture, whether the cement sheath has channeling and poor bonding problems, and whether the wellhead device and downhole tools are sealed reliably. In view of the characteristics of high pressure, high production and high sulfur content of high water production gas wells, the bearing capacity and sealing performance of the wellbore under measure construction pressure (such as acidizing and fracturing construction pressure) and long-term production high pressure working conditions are mainly evaluated to judge whether there are safety risks such as blowout, lost circulation and natural gas leakage. If wellbore integrity defects (such as casing corrosion perforation and cement sheath channeling) are found, repair measures (such as casing patch and squeeze cementing) must be formulated first to ensure that the wellbore has the safety conditions for measure construction before carrying out subsequent treatment measures.

4.4 Suggestions on Measure Treatment

Based on the results of single well geological potential, life cycle stage and wellbore integrity evaluation, targeted measure treatment schemes are formulated, taking into account both productivity release effect and economy. For Jin A Well Block, drainage gas recovery technologies are adopted, including pumping unit, jet pump and ESP drainage. According to the gas well production, water cut, bottom hole pressure and other parameters, a suitable drainage process is selected to restore the normal gas production capacity of gas wells by reducing the bottom hole back pressure and eliminating water lock damage. The measure selection principles of this well block have been detailed above and will not be repeated here.

4.5 Economic Evaluation

Economic evaluation is the core index to measure the feasibility of measures for high water production gas wells, which needs to comprehensively consider measure input and expected benefits to ensure the economic rationality of measure implementation. A dynamic economic evaluation method is adopted to construct an economic evaluation model including investment cost, operation cost, sales revenue, taxes and fees. The investment cost mainly includes measure construction costs (such as acidizing and fracturing construction fees, drainage gas recovery equipment purchase fees), wellbore repair costs and technical service fees; the operation cost includes production maintenance costs (water haulage, water treatment) and equipment depreciation costs after the implementation of measures; the sales revenue is calculated based on the expected production after the implementation of measures and the natural gas sales price. At the same time, the annual profit and three-year profit are evaluated according to the above costs and profits, and a sensitivity analysis is carried out, focusing on the impact of natural gas price, measure validity period, production increase range and other factors on profits. If the cash flow of the three-year economic evaluation result is greater than 0, it indicates that the measure has economic feasibility; on the contrary, it is necessary to optimize the measure scheme (such as reducing construction costs and adjusting process parameters) or abandon the measure and choose a more economical alternative scheme.

5. Effect Analysis of Treatment Measures for High Water Production Gas Wells

A total of 13 well times of water-flooded measure operations were carried out in Jin 30 Well Block in 2025, including 10 pumping units, 2 jet pumps and 1 ESP. The total cumulative additional gas after measures was 7.63×10^6m^3, among which the cumulative additional gas of pumping units was 5.71×10^6m^3 with an average single well cumulative additional gas of 571×10^3m^3; the cumulative additional gas of jet pumps after measures was 544×10^3m^3 with an average single well cumulative additional gas of 272×10^3m^3; and the cumulative additional gas of ESP after measures was 1.381×10^6m^3.

5.1 Influence of Leakage on Pump Inspection Cycle

From the perspective of pump inspection cycle, the pump inspection cycle of the same type of drainage process is closely related to the leakage during operation. The production conditions of two pumping unit wells, JA-P1 and JA-P2, are analyzed and compared below.

For Well JA-P1, the cumulative leakage was 1334 m³ during the operation from November 10 to December 17, 2024. A sand washing string was run on December 5, 2024, and the tonnage of lifting and lowering at the pipe shoe position of 3736.55 m was normal without any stuck phenomenon. On December 6, 203 strings of φ73 mm N80 external upset chamfered sand washing strings were lifted, with a total of 303 strings unfinished, and wellbore overflow was found. The well was shut in on site, the pump truck pipeline was connected, and positive circulation well washing was carried out with a 700-type pump truck at a pump pressure of 3 MPa and a discharge rate of 700-800 L/min. The liquid used for circulation well washing was 180 m³ with a leakage of 60 m³. (2) The adaptive drainage process upgrading operation was carried out from March 18 to April 5, 2025 without sand washing, with a cumulative leakage of 99 m³. (3) The leakage was 128 m³ during the milling process of the load reduction deep pumping operation from June 21 to July 9, 2025. The cumulative leakage of this well during the operation was large. It was put into pumping on July 21, and the indicator diagram showed stuck and shutdown on July 26. Well washing operation was carried out on July 29 with 120 m³ of water at a pump pressure of 5 MPa and a discharge rate of 500 L/min. After washing, the polished rod still encountered resistance 2 m below the upper dead center. It is inferred that there is sediment deposition at the lower part of the load reducer, resulting in the failure of the sucker rod to run down normally, and the well is currently shut in. The liquid sample of this well is black and opaque with sediment deposits, the average daily gas production during production is 752 m³, the cumulative gas production is 3006 m³, and the normal production is only maintained for 4 days.

For Well JA-P2, the cumulative leakage was 460 m³ during the pump inspection operation from June 22 to July 30, 2025, and the well was completed on July 29, 2025 with the ESP plunger depth of 3508.36 m. The liquid sample of this well is brown translucent liquid with a small amount of suspended solids. It was put into pumping on August 9 with a stroke of 7.3 m and a pumping speed of 1.2 N/min. At present, the daily gas production is 5×10^3m³ and the daily liquid production is 20.3 m³, maintaining stable production up to now.

5.2 Effect Analysis of Process Types

For the three different types of mechanical drainage measure wells, the effects are different, and even for the selection principles of mechanical drainage types, the effects may not correspond to the theoretical direction. The two measure wells using jet pump drainage failed to achieve the expected effect, with an average cumulative additional gas of about 321×10^3m³ per well in the year, far lower than the average single well cumulative additional gas of 587×10^3m³, and the average pump inspection cycle is 24 days. In addition, the liquid discharge capacity is similar to that of pumping unit drainage without obvious advantages. ESP drainage has a good effect on gas wells with extremely high water-gas ratio, with a cumulative gas production of 1.381×10^6m³ in the year and a stable liquid discharge capacity of more than 60 m³/d. Pumping unit drainage has the characteristics of low cost and strong stability, and preventing leakage during operation is the key work of pumping unit drainage. Pumping unit measure wells with small leakage often achieve good effects. To sum up, for gas wells with a liquid production of more than 50 m³/d, ESP drainage can support the production resumption of gas wells; for gas wells with a liquid production of less than 50 m³/d, it is recommended to use the pumping unit drainage process with lower cost and better stability for all.

6. Summary

Aiming at the problems of increasing high-water-content gas well and ineffective production resumption by conventional processes in Jin A Well Block of Dongsheng Gas Field (a low-pressure, ultra-low permeability and high water cut tight gas reservoir), this paper systematically discusses the demonstration process, treatment types and application effects of water-flooded well measures, and draws the following conclusions:

(1) The development intervals of Jin A Well Block are the Lower Shihezi Formation and Shanxi Formation of the Lower Permian in the Upper Paleozoic, with poor reservoir physical properties, deep burial and low pressure coefficient, and significant high water production characteristics (an

average water-gas ratio of 9.0 $m^3/10^4m^3$). The production resumption of high-water-content gas well needs to be comprehensively demonstrated in combination with reservoir geological conditions, gas well production status and wellbore safety.

(2) The demonstration process of water-flooded well measures in Jin A Well Block needs to carry out single well geological potential analysis, gas well life cycle stage determination, wellbore integrity evaluation, measure treatment scheme formulation and economic evaluation in turn, which provides a complete basis for well selection in measure implementation.

(3) A total of 13 well times of water-flooded well treatment were implemented in this block in 2025, adopting three types of mechanical drainage processes: pumping unit, jet pump and ESP, and the application boundaries of various processes were clarified: the pumping unit is suitable for gas wells with a daily liquid production of less than 20 m^3, the jet pump is suitable for gas wells with a daily liquid production of 20-50 m^3, and the ESP is suitable for gas wells with a daily liquid production of 50-100 m^3. However, there are differences between the actual application effects and the theoretical boundaries.

(4) The treatment effect analysis shows that the ESP has the best production resumption effect on gas wells with high liquid production (more than 50 m^3/d) and extremely high water-gas ratio, with a single well cumulative additional gas of $1.381\times10^6m^3$ and stable liquid discharge capacity; the pumping unit process has the characteristics of low cost and strong stability, suitable for gas wells with a daily liquid production of less than 50 m^3/d, and its effect is key to controlling the leakage during operation, and wells with small leakage can achieve stable production; the jet pump process fails to meet the expected effect, with both single well cumulative additional gas and pump inspection cycle falling short of expectations, and no obvious application advantages.

(5) ESP drainage is adopted for gas wells with a daily liquid production of more than 50 m^3/d, and pumping unit drainage is preferred for gas wells with a daily liquid production of less than 50 m^3/d. At the same time, the operation leakage must be strictly controlled to extend the pump inspection cycle and improve the treatment effect.

The research results of this paper not only provide direct technical basis for the subsequent demonstration, well selection and process selection of water-flooded well measures in Jin A Well Block, but also offer a reference for the production resumption of high-water-content gas well in similar low-pressure and high water cut tight gas fields in China.

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