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Research on Dynamic Monitoring System of DengSi Gas Reservoir in Moxi Block of Anyue Gas Field

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Abstract

The Dengsi gas reservoir in the Moxi block of the Anyue super large gas field in the Sichuan Basin is a high-temperature and atmospheric pressure large-scale lithologic stratigraphic composite enclosed gas reservoir. The storage space is mainly composed of small and medium-sized karst caves and various types of dissolution pores. The overall performance of the reservoir is low porosity, low permeability, and strong heterogeneity. The fourth gas reservoir in the Moxi platform edge zone is currently in the early stage of stable production, and there are problems such as interference between some well groups, poor reservoir seepage characteristics of some gas wells, blockage of some gas wells, water invasion, etc., which result in limited production. The dynamic reserves of the stacked gas wells with well control radii have significant differences in calculation results at different periods, and the dynamic temperature and pressure monitoring system for gas well production is incomplete, There is an urgent need to establish a unified production dynamic monitoring system suitable for the four gas reservoirs along the Moxi platform edge.

Keywords

Moxi Block; Deng Si Gas Reservoir; Dynamic Monitoring; Interwell Interference.

1. Introduction

The fourth group gas reservoir in the Moxi platform edge zone of Anyue Gas Field is a super large carbonate gas reservoir with edge and bottom water in China. There is no mature development experience in this type of gas reservoir in China, and there is a lack of systematic dynamic monitoring system[1]. This article focuses on the challenges and key technical issues faced by gas reservoir dynamic monitoring work. Through active exploration, continuous improvement, and innovation of dynamic monitoring technology and analysis methods, a dynamic monitoring system suitable for the four groups of gas reservoirs with lights at the edge of the Moxi platform has been constructed[2]. Five key dynamic monitoring technologies, including pressure and temperature dynamic monitoring technology, production capacity monitoring and evaluation technology, fluid property monitoring technology, water invasion monitoring and identification technology, and well connectivity monitoring and evaluation technology, have been developed for the four gas reservoirs in the Moxi platform edge zone[3]. Scientific and reasonable development measures have been formulated to support the preparation of the overall water control plan for the gas reservoir, It has played a role in ensuring the scientific and efficient development of large-scale edge and bottom water carbonate gas reservoirs[4].

2. Dynamic Monitoring System for Gas Reservoirs

Based on the different development stages and characteristics of the four gas reservoirs in the Gaoshiti Moxi block, combined with dynamic monitoring methods and process technology research, a gas reservoir seepage characteristics, production capacity and stable production

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capacity monitoring, inter well connectivity, water invasion monitoring, and temperature and pressure monitoring system has been established[5]. A unified dynamic monitoring system for the four gas reservoirs in the Gaoshiti Moxi block has been formed, and applied to development practice. All development dynamic data have been accurately obtained, Effectively supporting the scientific and efficient development of gas reservoirs.

2.1. Monitoring System for Seepage Characteristics, Production Capacity, and Stable Production Capacity

The monitoring objective of the seepage characteristics of the Dengsi gas reservoir in the Moxi platform edge zone is to diagnose the flow mode of a single well, the formation pollution near the bottom of the well, the reservoir characteristics, reservoir physical properties, and boundary types based on the understanding of the geological characteristics in the early stage, combined with the identification of unstable well testing curves, in order to understand the seepage characteristics of the gas reservoir. By comparing and analyzing the characteristics of unstable single well testing curves in different periods, further understanding the formation pollution or improvement near the bottom of the well, changes in reservoir physical properties, and activity of edge and bottom water, and analyzing the reasons for changes in gas well production[6].

The production capacity monitoring of the Dengsi gas reservoir in the edge of the Moxi block is aimed at understanding the production capacity of gas wells, analyzing the reasons for production capacity changes, and factors affecting production capacity.

Currently, two types of production capacity monitoring methods have been established based on production capacity testing and production performance data RTA data simulation for gas reservoir production capacity characteristics. Compared with the conventional one point method, the modified one point method for well classification improves the calculation accuracy by 6.75% and can be used for rapid evaluation of gas well productivity. The proposed production capacity calculation method based on production dynamic data RTA simulation has an average error of 14.77% between the calculated open flow rate and the measured value, which has certain accuracy and meets the requirements of gas well production capacity evaluation.

According to the development stage, a production capacity monitoring system is developed, which is mainly divided into the following two stages according to the development process of gas wells. The monitoring objectives and methods for each stage are shown in the table below.

Table 1. Production Capacity Monitoring System for Four Gas Wells with Lamp on the Platform Edge of Moxi Block

Stage	Purpose	Process technology	Analytical methods
Early stage	One point evaluation method for determining gas well productivity formation	Steel wire suspension pressure measurement	One point well testing
		Steel wire suspension testing well	Backpressure testing
Stable production and adjustment period	Verification and Correction of Production Capacity Changes in Monitoring Gas Wells by One Point Method	Steel wire suspension pressure measurement	Correction point method
		Steel wire suspension testing well	Backpressure testing
		Daily wellhead production and oil pressure monitoring	Based on dynamic RTA production capacity calculation

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2.2. Interwell Connectivity Monitoring System

Based on the geological characteristics of the Deng4 gas reservoir in the Moxi block platform edge zone, a monitoring concept of "static state before dynamic state, internal well group before external well group, and main body before periphery" is proposed, and a monitoring system for inter well connectivity and reserve utilization of the Deng4 gas reservoir in the Moxi platform edge zone in Anyue is established.

In the early production stage of development, the goal is to monitor the connectivity within the well cluster. During the trial production period, static pressure is measured at each point before each well is put into production, and the connectivity between wells is qualitatively determined through the initial pressure drop; In addition, closely monitor the changes in wellhead oil pressure and production of adjacent wells after the well is put into operation. At the same time, it is possible to consider selecting key well groups for unstable well testing, monitoring whether there is an initial pressure drop in subsequent production wells within the well group, and determining the connectivity within the well group based on the impact of subsequent production wells on adjacent production wells.

The stable production stage and production decline stage of gas reservoirs aim to monitor the connectivity between well groups, as well as the connectivity between the periphery and the main body, and make qualitative or quantitative evaluations. Conduct RTA well control radius analysis and production performance analysis to qualitatively evaluate the connectivity between well groups, in order to achieve the goal of understanding the differences in connectivity between low permeability and high permeability areas. Finally, through unstable well testing, targeted quantitative evaluation of connectivity differences between high permeability and low permeability areas, as well as monitoring of connectivity between well groups, will be carried out. For well groups that require key monitoring of connectivity, unstable well testing can be carried out at a specific time.

Through the established inter well connectivity monitoring system, 7 wells in the gas reservoir have been monitored for early pressure drop, and there is connectivity in 7 well groups. It is recognized that the overall connectivity of the gas reservoir is poor, and only the internal sub wells of Gaoshi 1 well block and Moxi 108-111 well block have connectivity.

2.3. Water Intrusion Monitoring System

Based on existing data, it can be recognized that the DengSi gas reservoir in the Moxi block platform edge zone is a gas reservoir with edge and bottom water and locally sealed water. Risk water invasion identification runs through the entire development stage of the DengSi gas reservoir in the Moxi block platform edge zone[7]. The monitoring of water invasion in gas reservoirs should be combined with static and dynamic methods. The geological model should be continuously modified to identify water invasion risk wells in static state, and the production characteristics of water invasion risk wells should be tracked and identified in dynamic state to predict water invasion.

In response to the problems faced by water invasion monitoring in the Deng4 gas reservoir at the edge of the Moxi block, a monitoring concept of "key well selection and appropriate methods" is proposed to establish a water invasion monitoring system. The purpose of water invasion prediction is to identify the occurrence of water production in advance before the gas well produces water, in order to adjust the production system of the gas well to delay water invasion, extend the water free gas production period of the gas well, or further develop targeted measures to improve the recovery rate of the gas reservoir. The main monitoring methods used include hydrochemical characteristics method, production performance method, and unstable well testing method. The monitoring content includes the hydrochemical characteristics of the produced liquid, changes in liquid production volume, changes in water gas ratio, and changes in wellhead oil pressure.

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By conducting water invasion monitoring of the fourth gas reservoir in the edge zone of the Moxi block, combined with static geological understanding of the gas reservoir, and using logging and production performance data, it is comprehensively determined that there is edge and bottom water in the northern Moxi 108-111 well area, and there is local sealed water in the central Moxi 102 well, Moxi 022-X2 well, and Moxi 022-X40 well. Currently, Moxi 022-X40 and Moxi 022-X41 well are suspected to be producing layer water.

2.4. Temperature and Pressure Monitoring System

Conduct adaptability analysis on six conventional pressure and temperature monitoring processes, compare process characteristics and applicable scenarios, and recommend four processes (wire suspension well testing, wellhead oil pressure monitoring, simple hanger and support cylinder pressure testing); Based on the characteristics of high temperature, high pressure, and medium sulfur content in the work area, sulfur resistant steel wire and storage pressure gauge were selected, and the wire suspension well testing process was improved.

Analyze and summarize three permanent pressure and temperature monitoring processes, and compare them in terms of usage time, cost, resolution, and other aspects. The electronic permanent monitoring process has advantages in later management, well entry method, and cost, and has applicability. It is recommended that the work area conduct experiments on water invasion risk wells. At present, the fourth gas reservoir at the edge of the Moxi block has obtained 96 well point pressure and temperature data, 38 well special well test data, and all wells have obtained pressure data through wire testing technology, which is the foundation for establishing a unified gas reservoir dynamic monitoring system.

2.5. Unified Monitoring System for Production Dynamics

Based on the current monitoring well network of two lines and one ring in the four gas reservoirs at the edge of the Moxi block, combined with the geological characteristics of the work area, following the concept of "well area combination, highlighting key points, and timely adjustment", targeting "points (20 key wells) and areas (four areas)", the monitoring objects and objectives at different development stages are clearly defined; In response to the three major monitoring purposes, a dynamic monitoring system of "two vertical and one ring" is established based on the idea of "considering both regular and special aspects, highlighting practicality".

Starting from the actual situation of the gas reservoir, the strategic goal of dynamic monitoring of the gas reservoir is established first, and then the principles, content, and monitoring plan of dynamic monitoring are formulated. Through the development of dynamic monitoring implementation steps and strategies, process supervision and quality control are strengthened, and various dynamic monitoring work is carried out strictly in accordance with the dynamic monitoring technical plan and operating procedures; Fully utilize the collected data to conduct production performance analysis and evaluate the implementation effect of the gas reservoir dynamic monitoring plan; Based on the evaluation results of the implementation effect of gas reservoir dynamic monitoring, the technical content of gas reservoir dynamic monitoring will be optimized and improved, ultimately forming a unified production dynamic monitoring system for Dengsi Gas Reservoir in Moxi Block of Anyue Gas Field.

2.6. Application of Dynamic Monitoring System

The successful establishment of the two ring and one line dynamic monitoring system has made great progress in the following aspects of gas reservoir dynamic monitoring: deepening the understanding of the overall development dynamic characteristics of the gas reservoir, clarifying the impact law of water invasion, establishing the seepage characteristics of "full coverage on the plane, full time period of key wells, and all directions of abnormal wells", and clarifying the current well to well connectivity of the gas reservoir.

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The system can accurately monitor the distribution and changes of gas reservoir pressure, gas-water interface and gas reservoir boundary, production capacity changes and stable production capacity, inter well connectivity, water invasion performance, and fluid properties. The specific application results are as follows:

a. The dynamic characteristics of the development of the Deng4 gas reservoir in the platform edge zone have been clarified, and the overall stable production capacity is strong, with some wells showing decreasing or blocking characteristics.

b. Research on optimized production allocation was conducted using gas production curve indication method, production dynamic method, etc., effectively guiding on-site production.

c. For the first time, a "two lines and one ring" dynamic monitoring system has been established, selecting suitable monitoring processes, and clarifying key monitoring objectives and tasks.

d. In response to the monitoring of water intrusion, a development technology policy has been established for the first time, which includes controlling water blockage, fine development, and replacing stable production.

3. Conclusion and outlook

(1) The next step is to continue utilizing the established gas reservoir production capacity monitoring well network, mainly targeting wells that have not undergone production capacity testing and key well groups. Key wells should be selected for production capacity testing, covering water invasion risk wells and low permeability areas, in order to achieve the goal of monitoring production capacity changes and analyzing factors affecting production capacity.

(2) The traditional well testing method requires a crane, blowout prevention device, well testing truck, and well testing personnel to stay at the well site for a long time, which requires a lot of manpower and material resources. It does not meet the requirements of long-term continuous monitoring of bottom hole pressure. The simple release device is limited by the structure of the pipe column and has limited application range. It is recommended to carry out the development and testing of mechanical release devices.

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