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Development and Application of Multi-condition Intelligent Control Valve

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SUMMARY: *The conventional shale gas production methods usually have a complex network of control systems at the wellheads which can be controlled by several autonomous parts. This de-centralized configuration causes system instability and higher maintenance expenses. To solve these problems, one of the solutions proposed in this work is the intelligent control valve which combines sensors, regulating valves and control units into a unified system, simplifies the structure of the wellhead control system, increases the efficiency of regulation and enhances the stability of the system. Multiple control modes, including production control mode, pressure control mode, and piston gas lift mode are available in the intelligent control valve, which allows it to adapt to changing production conditions flexibly and optimize gas production rates and economic benefits at the wellhead. Results indicate that the intelligent control valve exhibits excellent stability and meets the remote control requirements of gas wells. After installing the intelligent control valve, the average daily gas production of Well A increased significantly, from* 2.14×10^4 *m³/d to* 2.34×10^4 *m³/d, representing a 6.86% increase compared to pre-installation levels. The average gas production efficiency improved by 5.44%, with good drainage and gas production effects. The single-well intelligent control valve system can generate an economic benefit of 355,600 yuan within six months, demonstrating high potential for promotion and application.*

KEYWORDS: *shale gas; wellhead control system; intelligent control valve; remote control*

1 Introduction

Currently, shale gas development both domestically and internationally primarily employs cluster horizontal well development, sand-enhanced fracturing, and rolling development methods. This results in shale gas wells exhibiting characteristics such as high water production and sand volume during the initial development phase, rapid decline in production capacity and pressure, and prolonged low-production, low-pressure conditions during the later stages of development, though with extended production cycles [1-4]. After over a decade of exploration and practice, based on the characteristics of shale gas field development, ground engineering construction has gradually formed a standardized system centered on “standardized process flows, modular functional zones, skid-mounted high-efficiency equipment, series-based device combinations, and digital management,” providing a reference framework for shale gas ground construction. In shale gas engineering, control valves play a crucial role [5-8].

Traditional electric valves primarily rely on mechanical devices such as limit switches and torque switches to achieve valve position signal feedback and process monitoring, which are

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prone to mechanical wear and poor contact [9, 10]. With the advent of the intelligent era, an increasing number of devices are being upgraded with intelligent features. As a critical component of control equipment, shale gas valves are also gradually being incorporated into intelligent upgrades [11-13]. Intelligent control valves achieve bidirectional communication with control systems via fieldbus, industrial Ethernet, and other communication methods, supporting remote parameter settings, status monitoring, fault diagnosis, and other functions [14-16]. The ICON3000 intelligent electric actuator from BIFFI Company in the United States adopts multiple communication protocols such as HART and Profibus, and features rich diagnostic functions such as remote valve position feedback, torque curve analysis, and seal aging assessment, achieving intelligent management of the entire lifecycle of valves [17, 18]. Remote monitoring and diagnostic functions simplify on-site operations, improve system operational efficiency, and reduce maintenance costs, which are prominent characteristics of intelligent electric valves [19-21]. Intelligent control valves not only play a role in shale gas extraction but are also widely used in buildings, liquid transportation, water supply, and other fields, enabling remote control, monitoring, and management of pipelines [22-24].

Given the current complex wellhead operations, frequent well switching, high risks associated with manual operations, and high labor intensity, this study designed an intelligent control valve suitable for various operating conditions to replace manual needle valves at wellheads. The valve integrates remote intelligent production control technology, online production optimization technology for gas wells, and other technologies, offering multiple operational modes such as intelligent production control, pressure control, intermittent opening, piston gas lifting, and high/low-pressure protection. It enables autonomous and remote management of shale gas well production.

2 Intelligent control valve structural design

2.1 Basic Structure and Principles of Valves

2.1.1 Basic Structure

The basic structure of the intelligent control valve is shown in Figure 1. It consists of a valve body base (1), a valve stem base (2), a valve stem (3), a valve core (4), a mechanical limiter (5), a control system (6), an electric actuator (6), a mechanical valve position (7), a pressure and temperature sensor (8), and a piston arrival sensor (9), among other components [25]. In actual operation, the valve stem drives the valve plug to move axially along the main body structure of the needle valve. When closing the valve, the valve stem drives the valve plug to move downward, causing the valve plug to contact the valve seat and elastic components. Through continuous compression of the valve plug by the elastic components, the valve achieves sealing. The mechanical limiter is set to limit the compression of the valve plug against the valve seat. Once the compression limit is reached, the valve core is prevented from further compressing the valve seat, thereby avoiding the issue in existing technologies where “excessive compression of the valve seat may damage the sealing surfaces of the valve core or valve seat.”

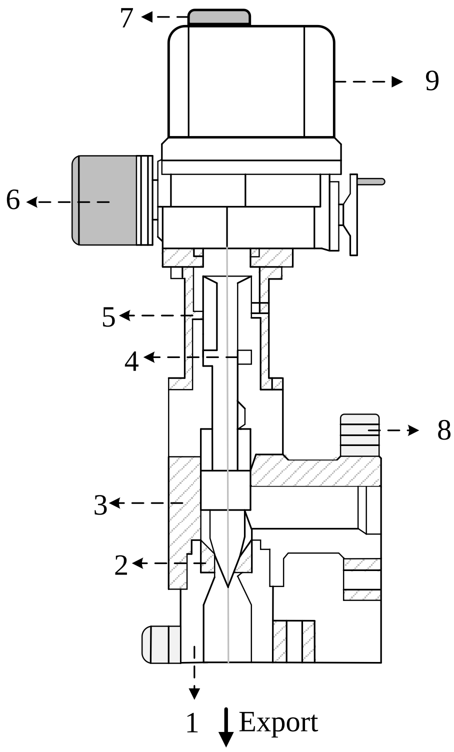


Figure 1: Basic Structure of intelligent Control valves

When the valve is opened, the valve stem moves the valve core upward, causing the valve core to separate from the valve seat and elastic components until the valve is fully open. The valve features two operating modes: manual and intelligent. In manual mode, the handwheel is connected to the clutch, which is in turn connected to the gear set. Turning the handwheel operates the needle valve. In intelligent mode, the needle valve is operated via a motor, reducer, gear set, splined shaft, and drive head.

2.1.2 Working Principle

An intelligent control valve is an intelligent automated control device. It primarily consists of a control system, data transmission equipment, pressure and temperature sensors, a piston position sensor, and a valve body, with its operating principle illustrated in Figure 2.

(1) The controller incorporates hydraulic pressure, pipe pressure, casing pressure, temperature, and valve position sensors with an accuracy of less than 0.2 per cent FS to accurately monitor the data and store the production data over a period of almost 30 days. The system has interface with the oil field production data platform to facilitate remote control and management. Under operating conditions, the controller has the ability to send operational commands to regulate the valve opening degree with a level of control precision higher than Grade 2.5.

(2) Pressure sensors transform fluid pressure into electrical signals and send them to the control system, allowing accurate control over oil pressure, pipe pressure, and casing pressure to make sure that the system is working with acceptable levels. Additionally, in pressure control mode, the controller can adjust valve opening based on pressure data feedback from sensors, enhancing system responsiveness. The pressure sensor has a pressure range of 0-70 MPa, with a temperature drift value of 0.05% FS/°C, minimizing the impact of temperature on data monitoring.

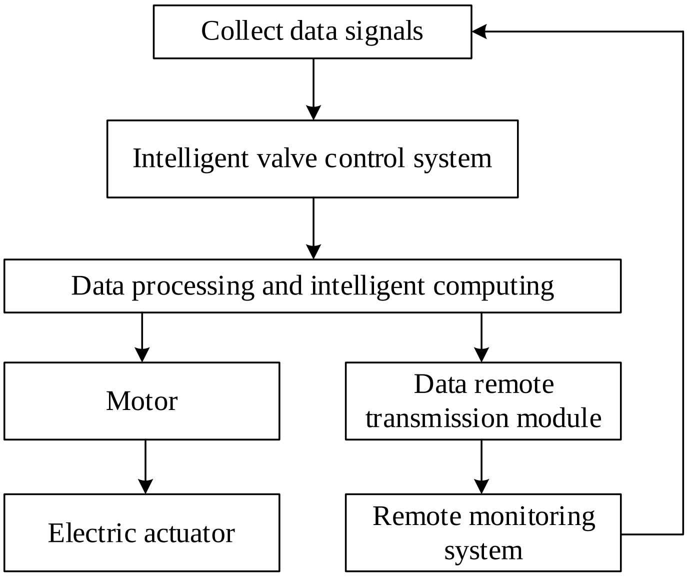


Figure 2: Working principle of the intelligent control valve

(3) The temperature sensor converts temperature changes into electrical signals via a temperature-sensing element, which are then fed back to the control system to enable real-time transmission of temperatures before and after the valve. The temperature sensor is powered by a constant current source, with a temperature measurement range of -50 to 100°C and an error range of ±1°C.

(4) As part of valve control, the valve position sensor monitors the valve opening to ensure that valve movement aligns with control commands and prevent abnormal regulation. The system can combine valve position sensor data with pressure and flow data for intelligent regulation, improving regulation accuracy, with a measurement range of 0-50 mm.

(5) The motor can control the valve opening value or fully open/close the valve based on controller output commands, optimizing wellhead flow, pressure, or gas lift effects to achieve intelligent control. The motor can respond quickly, and it can make fast adjustments to changes in the conditions under which the production takes place to maintain a steady system operation.

(6) This piston arrival sensor is mainly employed in piston gas lift mode which helps in real time and precise monitoring of the piston arrival state, it gives information about the state of operation of the piston and it is used in determining if the piston has arrived at the predetermined position during the gas lift process so as to promote smooth motion of the piston and enhance its lifting efficiency. The sensor has a maximal sensing range of 0.5m with a 100 percent sensing percentage.

(7) The data conversion and transmission module can be optionally selected and customized. It translates the analog signals sensed by the pressure, temperature, valve position, and piston arrival sensors into digital signals, and sends them to the control system or remote monitoring facility. The remote transmission module is included in the controller to allow remote monitoring and control.

2.1.3 Main parameters

Nominal pressure: 80 MPa;

Nominal diameter: DN65;

Working medium: Natural gas (shale gas);

Working temperature: -40 to 80 °C;

Working voltage: DC24V;
Material grade: EE (acidic environment);
Full stroke time: 500 s;
Communication interface: RS485 (MODBUS-RTU);
Protection rating: IP67;
Product specification level: PSL3;
Performance level: PR1;
Manufacturing standard: API 6A standard;
Electrical connection: Explosion-proof cable leads;
Valve body material: A105;
Product power: 100W (maximum), 1W (standby);
Maximum output torque: 150 $N \cdot m$.

2.2 Design of Intelligent Control System for Gas Wells

2.2.1 Overall Technical Solution

The intelligent control system for gas wells consists of a remote control terminal, wellhead casing pressure, gas pressure, pipeline pressure, flowmeter, intelligent needle valve, emergency shut-off valve, and power supply system [26].

The intelligent control system for gas wells is shown in Figure 3. During operation, the monitoring center sends commands to the remote control terminal via a wireless communication terminal. After receiving the commands, the remote control terminal performs the corresponding well opening or closing actions according to the program module. Under normal conditions, the system continuously monitors the parameters of casing pressure, gas pressure, pipeline pressure, and flow meters. The remote control terminal controls the wellhead cutoff valve and electric needle valve through the control actuator, gradually increasing the opening of the intelligent control valve based on changes in oil pressure and pipeline pressure until the valve is fully open. When abnormal conditions occur during gas well production, the system automatically sends an alarm to the control center and performs an emergency well closure action.

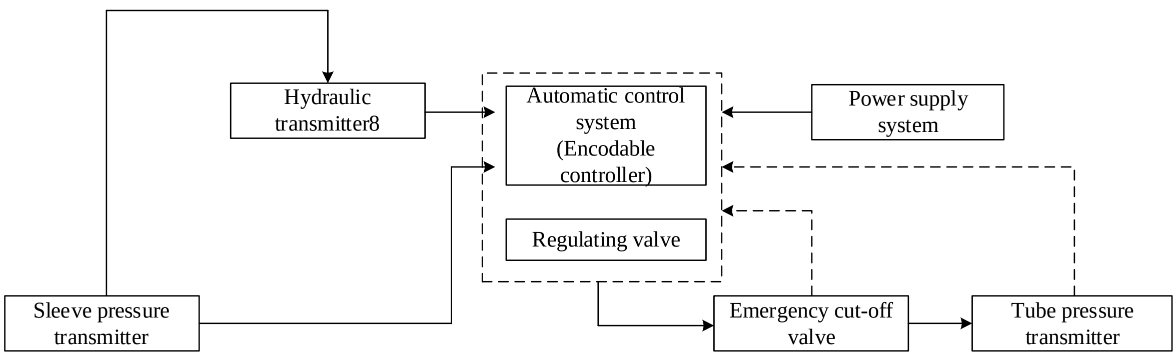


Figure 3: Schematic diagram of the intelligent control system for gas Wells

2.2.2 Remote Control Terminal

The Remote Terminal Unit (RTU) has the main task of gathering signals at industrial facilities and remote control of equipment. An RTU usually contains a variety of input/output ports, is capable of transmitting signals in many different ways, and may be fitted with any number of functional modules depending on what it is being used to do.

The modular structure design used by the RTU designed in this paper to be applied to shale gas wells is illustrated in Figure 4. Every module is designed separately. In order to avoid mutual interference between modules, it should be protected against interference by applying appropriate isolation protection measures. Also, the module power supply design requires a reference power supply. Mutual isolation of modules and usage of own independent CPUs are ensured. This arrangement does not only improve the reliability of devices but also greatly minimizes the load on the main control board enabling the processor on the main control board to undertake more complex computational and communication functions.

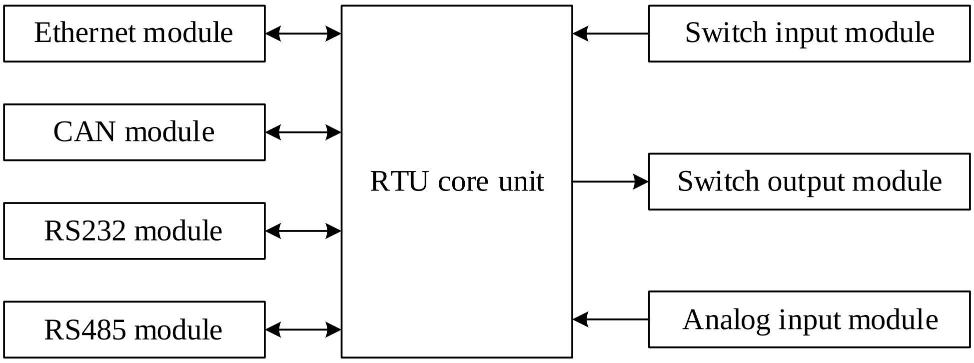


Figure 4: Overall structure of RTU

The remote control terminal in the intelligent control system of gas wells mainly provides data gathering and control of field actuators. The parameters of the pressure, flow rate, emergency shut-off valve status and intelligent control valves opening degree in the process of gas well production are sent through sensors and transmitters to the RTU to be transmitted to the higher-level computer through a wireless communication terminal to be analyzed and summarized. The chosen remote control terminal uses the microcontroller of the MSC-50 series that has better performance, stable working, and can be switched into low power mode, therefore it is widely used. Communication with external devices is carried out through RS485 by the remote control terminal.

2.2.3 System Software Design

The software system mainly has two parts, the host computer and the subordinate computer. The remote monitoring system software that is used in the host computer is based on PKS and Oracle databases, and it is well supported by Windows XP and Windows 7 operating systems which allow storing and displaying data. The lower level computer is run on the Keil Vision software debugging environment and communicates with the upper level computer through wireless communication to transmit data and exercise remote control. The lower level computer microcontroller program consists predominantly of the main program section, data acquisition subroutine, event handling subroutine, display refresh subroutine, and communication subroutine.

The low level computer monitoring program has an autonomous serial sequential structure. Once the system is initialized the main program calls each subroutine sequentially.

The upper-level machine remote monitoring system has system settings, real-time data display, and historical curve generation. The real time data that is displayed are air pressure, casing pressure, smart control valve opening, valve pressure, remote emergency shut-off valve status, flow rate and pipe pressure. Users have the ability to customize the tool menu by setting preferences including communication status message logging, alarm settings, alarm records, commonly used parameters, and user configurations.

3 Regulation process and control logic testing

3.1 Test Environment

Area A is a shale gas-rich region located at the southern border of the Ordos Basin and also falls under the category of tight gas reservoirs.After a period of production, the formation pressure near the wellbore gradually decreases, leading to a reduction in production pressure differential, which causes a decline in gas flow rate. When the gas flow rate falls below the critical liquid-carrying capacity, natural gas cannot carry liquid normally, resulting in the continuous accumulation of liquid droplets in the lower part of the wellbore. This increases the bottomhole flow pressure, ultimately reducing the gas production rate of the well, causing liquid accumulation in the gas well, and even flooding, rendering the gas well unable to produce normally.

Intermittent well switching production is a simple, efficient, and cost-effective production regime for liquid-accumulated gas wells, divided into manual intermittent switching and intelligent intermittent switching. Manual intermittent switching is time-consuming, labor-intensive, and inefficient, and is easily affected by factors such as transportation and weather, exposing operators to risks from dangerous driving and adverse weather conditions. To improve switching efficiency, this paper develops a multi-condition intelligent control valve system suitable for shale gas production. The controller is equipped with intelligent pressure control, production control, intermittent switching, piston gas lifting, high/low-pressure protection, and other control logic, as well as metering algorithms, to meet the full lifecycle management requirements of gas well production. This paper introduces the commonly used control modes of intelligent control valves, as shown in Figure 5, and conducts functional verification tests on Well A.

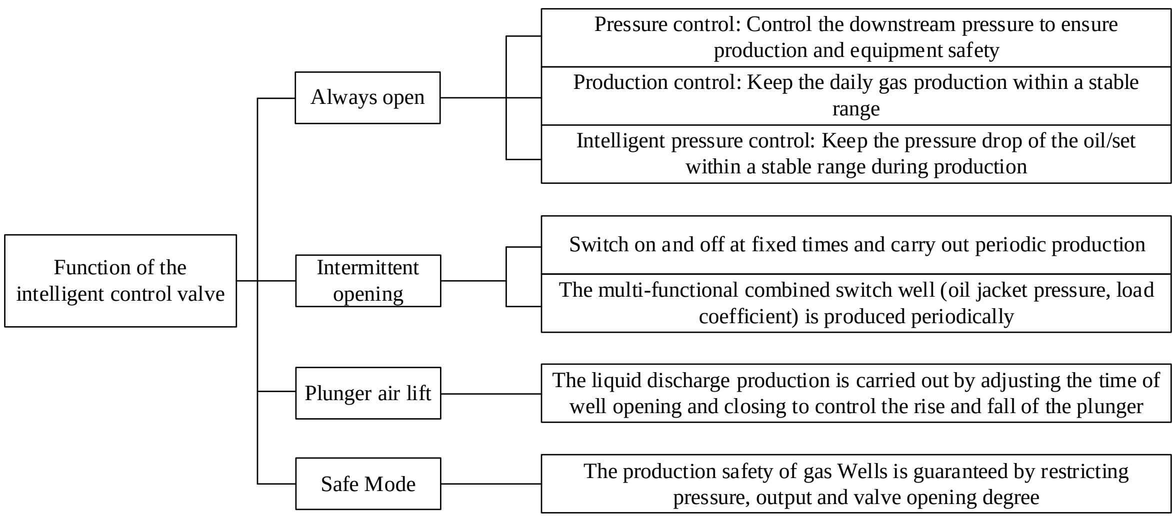


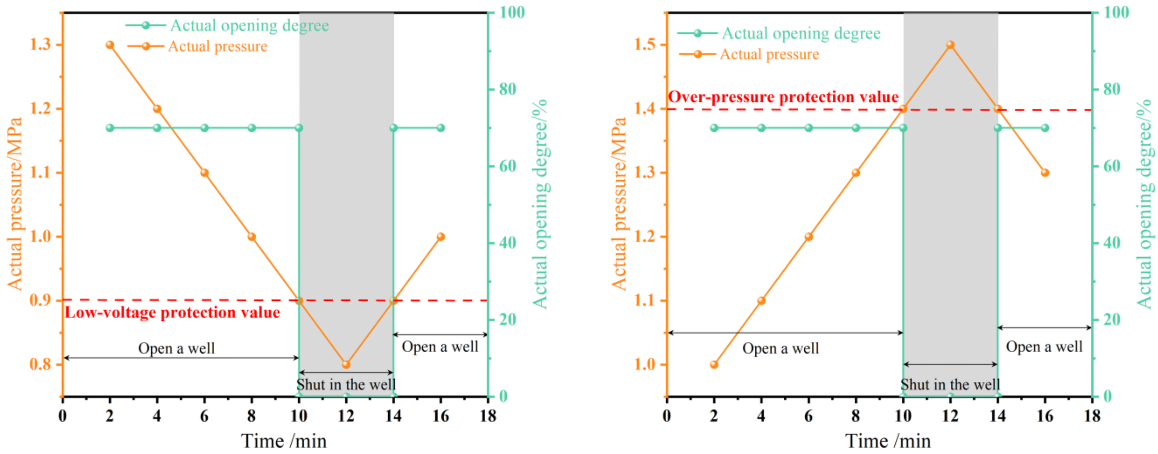
Figure 5: Summary of Control Modes

3.2 Control Logic Testing

3.2.1 Normally open - fixed opening

When operating in this mode, the valve maintains a fixed opening degree and is not adjusted during the production process. The opening degree value represents the percentage of valve opening. When set to 0%, the valve is closed, and when set to 100%, the valve is fully open. The opening degree value should be set between the valve's upper limit and lower limit. The controller defaults to normally open with a fixed opening degree, with an opening degree value of 0%.

This mode is used for temporary adjustments or infrequent adjustments, and can also be used for temporary equipment maintenance or other situations requiring manual intervention to control production volume, pressure, etc. A fixed opening effectively maintains gas flow, reduces production fluctuations caused by frequent valve changes, and ensures production stability. Set the maximum valve opening to 70%, increase the valve opening via the fixed mode, and test whether the valve triggers low-pressure and overpressure protection functions, with low-pressure protection and overpressure protection values of 0.9 MPa and 1.4 MPa, respectively. The test results are shown in Figure 6. It can be seen that the intelligent control valve can achieve low-pressure and overpressure protection. When the actual pressure is between the low-pressure protection value and the overpressure protection value, the valve's actual opening is fixed at 70%, and the protection function is not triggered. When the actual pressure is below the low-pressure protection value or above the overpressure protection value, the valve's actual opening quickly changes to 0%, i.e., it switches to a closed state, effectively preventing safety issues caused by abnormal pressure.



(a) Low-voltage protection test (b) Overpressure protection test

Figure 6: Fixed opening function test

3.2.2 Normally open - pressure control

Produce at a certain pressure, maintain stable downstream pressure, and set the reference valve opening to the current opening. In this mode, based on the set oil pressure range, automatically adjust the valve size (reduce the valve when the pressure exceeds the range, and increase the valve when the pressure is below the range) to ensure that the wellhead oil pressure value remains within the set range. The single adjustment ratio range is 0-100%, and the interval time between two adjustments can be set independently.

This model is applicable to situations where formation pressure fluctuates significantly and production varies. If the valve opening at the wellhead is fixed and cannot respond promptly to changes in formation pressure, downstream pressure will fluctuate accordingly. When downstream pressure fluctuates significantly, it may cause valves, pipelines, and other equipment to be subjected to excessive pressure changes, increasing equipment wear and failure risks. In severe cases, this may cause safety valves to trip or even lead to safety accidents. Additionally, low gas well pressure can easily lead to a large accumulation of liquid in the well, causing blockages in the wellbore. The valve maximum opening was set to 100%, and the pressure drop boundary was set to 0.8–1 MPa to test the pressure control function of the intelligent control valve. The specific test results are shown in Figure 7. It can be seen that the valve pressure control function can be used normally. When the time is within 25 minutes, since the actual pressure exceeds the upper boundary of the pressure drop, the intelligent control valve system detects the pressure changes and promptly takes measures to reduce the valve opening. At this point, the actual opening at the wellhead gradually decreases. After 25 minutes, when the actual pressure reaches the set range, the opening no longer changes and remains at 50% until the test ends at 55 minutes.

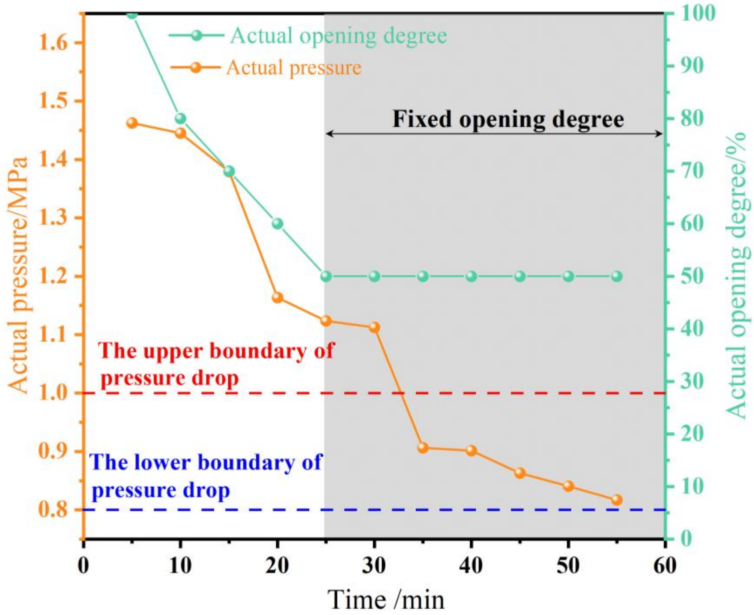


Figure 7: Pressure control Function test

3.2.3 Normally open - production control

Produce at a certain gas output rate to maintain stable gas output at the wellhead, with the reference valve opening set to the current opening. Set the gas output range to 0–100,000 m^3/h. During the judgment period, reduce the valve opening if the output exceeds the range and increase the valve opening if the output falls below the range. The single adjustment ratio range is 0–100%, and the interval between two adjustments can be set as desired.

In situations where reservoir pressure is relatively stable but gas production fluctuates significantly, the production control mode is more suitable. The primary objective of production control mode is to maintain stable gas production within a certain timeframe without directly adjusting wellhead pressure. It controls gas flow by adjusting valve opening to achieve stable gas production. When gas field development has entered the stable phase and reservoir pressure is relatively stable, production control mode can help maintain long-term stability of wellhead gas production, prevent production fluctuations, and meet production plans.

3.2.4 Normally Open - Intelligent Pressure Control

Produce at a constant pressure drop to maintain a stable rate of decline in wellhead pressure, with the reference valve opening set to the current opening. The range of the pressure drop is defined by comparing the average oil pressure at the present moment with the average oil pressure at the same time yesterday. The single adjustment ratio range is 0-100, and the period between two adjustments may be chosen as required.

Intelligent pressure control mode is mainly used at the early stage of production when the reservoir pressure usually decreases slowly. Intelligent pressure control mode allows keeping the steady rate of decrease of the wellhead pressure so that there would not be any abrupt changes in the pressure and the gas well would be produced on a steady basis over a long period of time. Managing the rate of pressure decline can help optimize the production potential of the reservoir without causing harm to the gas well or poor gas production performance due to excessive pressure decline. Open the maximum valve to 100% and use a pressure drop limit of 0.9-1.2 MPa and set the intelligent pressure control mode. The particular output is illustrated in Figure 8. It may be seen that in this mode, when the interval duration is set, the real pressure shows a constant reduction tendency. Until 25 minutes, the real pressure decrease is higher than the maximum pressure decrease limit, thus, the intelligent control valve reduces the real opening. Between 25 and 40 minutes, the actual pressure remains within an appropriate range, with the valve opening remaining unchanged. After 40 minutes, once the actual pressure drop falls below the lower boundary, the intelligent control valve increases the actual opening to mitigate the pressure decline rate.

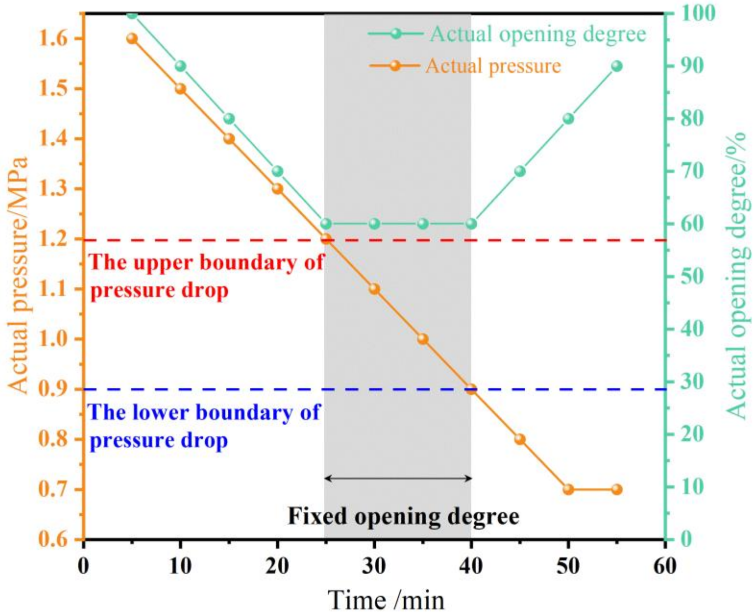


Figure 8: Test of Intelligent Pressure Control Function

3.2.5 Intermittent production

After operating the well for a certain period of time, it is shut down. After the well has been shut down for a certain period of time, it is reopened. Production is conducted in an intermittent manner according to a specific schedule. The conditions for opening and closing the well can be freely combined, but the duration of each opening and closing period must remain within specified limits. Under normal operating conditions, the valve opening degree in intermittent mode typically remains unchanged, with only two states: fully closed (0%) and fully open (at the valve's upper limit).

In some gas fields, it takes time for the pressure in underground gas reservoirs to recover. By intermittently opening and closing wells, the pressure in the gas reservoir can gradually recover during the closed period, thereby avoiding a sharp drop in pressure caused by excessive extraction. After each well closure, the recovery of reservoir pressure helps to increase gas flow and gas production efficiency during the next well opening. Set the upper limit of the valve to 70%, which is the well opening state, and test run in intermittent production mode. The results are shown in Figure 9. It is known that under the intermittent production mode, the actual opening degree exhibits periodic changes. The change cycle is 10 minutes, with a well opening time of 4 minutes and a well closing time of 6 minutes. The intermittent mode can operate normally within a given range.

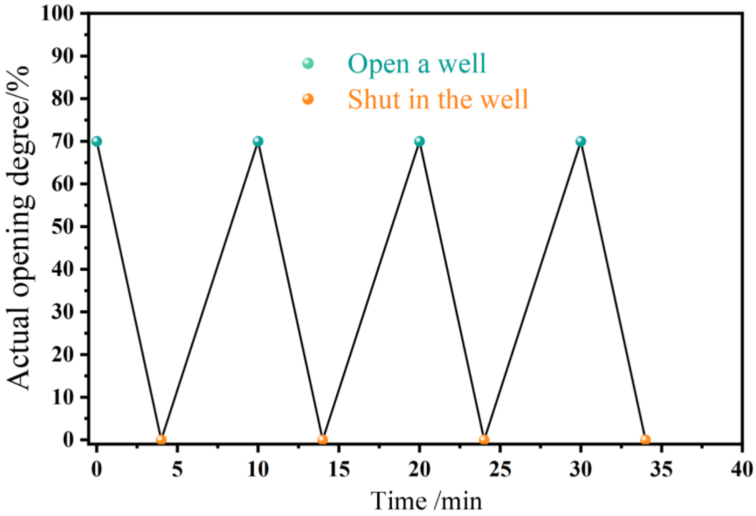


Figure 9: Interval opening function test

3.2.6 Piston gas lift

The piston reaches the sensor, and the relevant piston parameters are set to enable intermittent production based on the piston gas lift operation pattern. The valve opening of the piston mode valve typically does not change (unless triggered by safety settings), and only exists in the open and closed states, with the closed valve opening at 0% and the open valve opening at the valve upper limit.

When the formation pressure of a gas well is low and natural flow cannot achieve smooth gas extraction, the piston gas lift mode can effectively increase gas flowability. Gas can be pushed to the surface through periodic gas lift actions, ensuring continuous production of the gas well. This device uses a piston arrival sensor and controller to remotely capture and release the piston, eliminating the need for manual operation at the wellhead and eliminating the impact of piston fallback on gas well production. The arrival sensor can detect the piston from a distance of 0.5 meters with a detection rate of 100%. Its working principle is as follows: when the piston reaches the sensor, the sensor detects the piston's arrival and transmits an arrival signal to the piston controller. The piston controller sends a capture signal to the actuator, which reverses the motor, causing the piston capture device's push rod to extend into the inner wall of the blowout preventer, blocking the piston's descent and completing the piston capture; When the piston controller issues a shut-off signal, it simultaneously sends a release signal to the actuator. The actuator starts the transmission mechanism to rotate forward, retracting the push rod, allowing the piston to freely fall into the wellbore, completing the piston release.

4 On-site application results and evaluation

4.1 Comparison of yield increase effects

Well A was spud on July 25, 2019, completed on November 3, 2019, and cased on November 28, 2019, with a total depth of 3,923 m (vertical depth 2,835 m). From August 27 to September 6, 2020, fracturing was performed on the two reservoirs in the A well area, followed by a production test using a production tubing string. The absolute unobstructed flow rate of the well was calculated using the "one-point method" as follows: $Q_{AOF} = 41.25 \times 10^4 \text{ m}^3/\text{d}$ using the "one-point method." Production commenced in June 2020, but by the end of 2023, liquid accumulation occurred, necessitating frequent production interruptions and resulting in a decline in production efficiency. On October 25, 2024, the multi-condition intelligent control valve system designed in this paper (test version) was installed, as shown in Figure 10.

Figure 10: Physical pictures of intelligent control valves

After installing smart control valves in the A1-1 well, the gas production changes are shown in Figure 11. It can be seen that remotely controlling the opening and closing of the well based on production parameters such as gas volume and pressure reduces ineffective production time, improves the gas well production efficiency, and increases gas production accordingly.

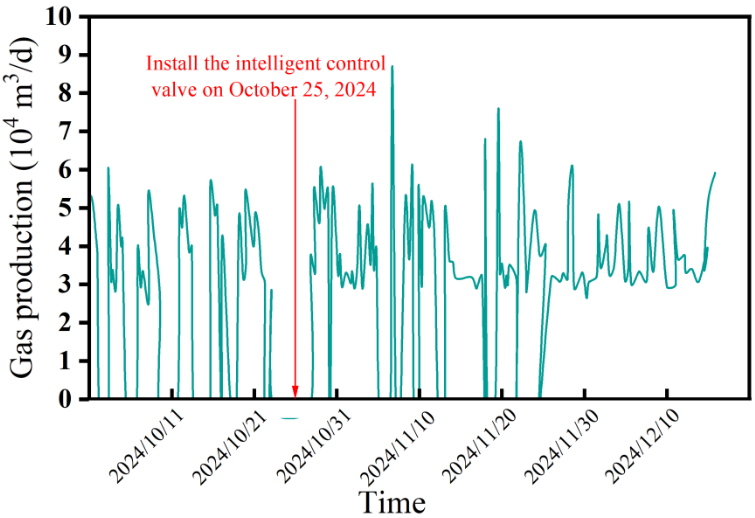


Figure 11: Changes in gas production before and after installation

The gas production of all 7 wells in Wellfield A (A1-1, A1-3, A2-2, A3-2, A3-3, A4-7, A5-1) has increased to varying degrees, with detailed information shown in Table 1. Among these, Output 1, Output 2, and Output 3 refer to the average production volume in the month prior to installation, the estimated average production volume in the month following installation, and the actual average production volume in the month following installation, respectively. Output 4 denotes the total increase in production volume six months after the intelligent control valve was put into use. As shown in the table, the gas production of six wells (excluding Well A2-2) was higher after installing the intelligent control valve. The estimated average production one month after installation was 2.14×10^4 m^3/d, and the actual average production one month after installation was 2.34×10^4 m^3/d, representing a 6.86% increase compared to before installation. The total additional production of Well A2-2 over the six months following installation was 24.15×10^4 m^3, indicating that the decrease in actual production one month after installation was due to the use of non-smart control valves. From the perspective of gas production efficiency, the well opening rate for 100% of gas wells has significantly improved.

Table 1: Production data tables before and after installation

Gas well	Installation date	Output 1 ($10^4m^3/d$)	Output 2 ($10^4m^3/d$)	Output 3 ($10^4m^3/d$)	Output 4 (10^4m^3)	Gas extraction time rate (%)
A1-1	2025/10/25	0.83	0.81	0.91	28.12	2.44
A1-3	2025/10/26	3.45	3.42	3.83	99.16	3.35
A2-2	2025/11/03	4.06	3.98	4.02	24.15	6.05
A3-2	2025/11/16	1.11	1.02	1.47	72.16	13.11
A3-3	2025/11/17	1.23	1.23	1.29	34.90	5.73
A4-7	2025/11/26	1.56	1.57	1.76	42.80	3.45
A5-1	2025/12/08	2.95	2.96	3.11	49.27	3.92
Mean		2.17	2.14	2.34	43.18	5.44

4.2 Economic evaluation

Figure 12 shows a comparison of the number and dosage of foam drainage gas injection and foam drainage agent treatments before and after the installation of the intelligent control valve at Well A1-1. As shown in the figure, prior to installation, from August 1, 2024, to October 25, 2024, over 86 days, there were 25 foam drainage treatments, averaging one treatment every 3.4 days. After installing the intelligent control valve, from October 26, 2024, to January 1, 2025, over 66 days, foam drainage was performed 7 times, averaging once every 9.4 days.

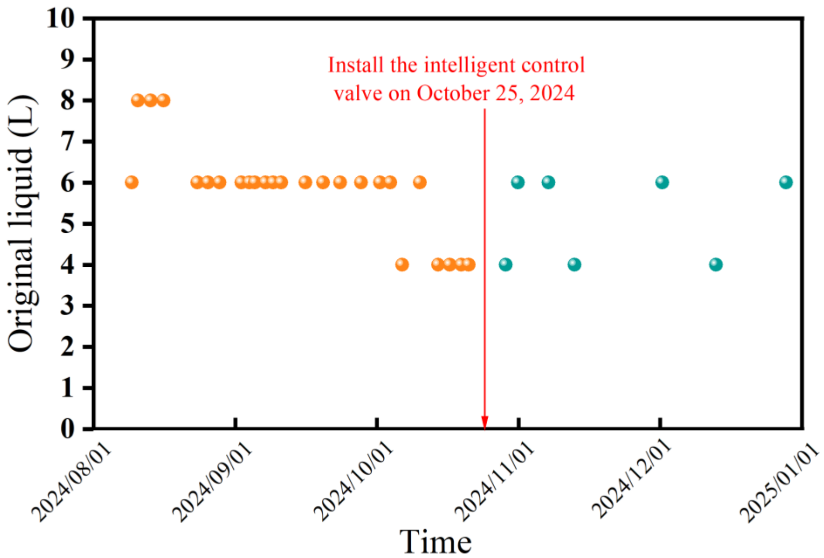


Figure 12: Comparison of the frequency and dosage of foam drainage before and after installation

After installing the intelligent air control valve at Well A1-1, by April 25, 2025, the increase in gas production over a six-month period was 28.12×10^4 m^3, with a total reduction of 23 bubble discharges. Assuming a cost of 600 yuan per bubble discharge (excluding time costs) and a gas price of 1.5 yuan per cubic meter, the cumulative economic benefit amounted to 435,600 yuan. The installation of an intelligent control valve system for one well costs approximately 80,000 yuan. In six months of operation, one well produced an economic gain of 355,600 yuan, which makes it evident that the economic performance of the intelligent control valve system is significantly better.

5 Conclusion

(1) The intelligent control valve has the major components including the pressure sensor, temperature sensor, valve position sensor, control systems and electric actuator. It may measure critical parameters like gas production rate, oil pressure, and casing pressure at the wellhead in real time and send the information to the control unit so that the valve can respond to real-time data with a quick adjustment.

(2) Intelligent control valve has several control modes available, including production control mode, pressure control mode, and piston gas lift mode allowing flexible switching when well conditions and production needs change. The intelligent control valve helps to have a steady wellhead operation at different production conditions, thus, making the gas wells more productive and secure.

(3) The field test findings indicate that once the intelligent control valve is installed on the gas well, the gas production rate of the gas well is maintained at a normal level, which indicates high levels of adaptability. As a fixed asset investment or in a lease service contract model, versus manual interval operations, the intelligent control valve system produced an economic benefit of 355,600 Chinese yuan over six months on research wells, indicating very good overall economic performance.

About the Author

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