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Innovation and application of an automatic control system for gas wells production in sulige gas field

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Abstract. In this paper, based on the advantages of imported control system and equipment, we designed a new type of automatic control system and equipment for gas well dewatering, by which the daily use of mobile phone can be used as a remote control terminal system. It has the advantages of convenient use, low cost, no need to design the PC software, free maintenance and upgrade PC software costs. Sulige Gas Field has used this system on 20 wells for mass operation test. The systems are till working until now, the equipment runs stably, and the economic benefit is remarkable. U disk data extraction is fast and convenient, and the management cost is reduced by 80%. The number of managing wells of per person is increased.

1. Introduction
The natural gas reserves in China has been built in the western South China Sea & Sichuan gas region and Xinjiang & Erdos oil and gas region [1], and China has gradually established a sound system of natural gas industry. Although China natural gas reserves are high, there is still a huge gap to be solved by importing [2]. With the development of monitoring technology of oil and gas field, an unattended remote monitoring system has appeared. It has significantly reduced the number of manual inspections and brought huge economic benefits, attracting the attention of Oil and Natural Gas Corp in land and abroad [3, 4]. The automation management of foreign oil and gas fields started early. It has entered a large number of applications in early stage of instrumentation automation, such as PLC, DCS and data acquisition and monitoring system (SCADA) [5]. The development of oilfield automatic control application is not balanced in China. The East oil and gas field represented by Daqing is mostly automated monitoring system of single production process, which fails to realize the automatic management of the whole oil and gas field. The western oil and gas field represented by Changqing has basically established the SCADA system of the whole oilfield. For the small oil and gas fields with low production and edge dispersal, there is basically no automatic monitoring of the production process, most of which are manual operation instead [6].
2. Comparison of the function of common control equipment in China
The commonly used gas well control equipment in the country is PCS4000 controller and Petro-Tech controller in the US, and WEATHFORD controller in Canada. The model of control equipment proposed in this paper is HC100. The function comparison of commonly used gas well control devices in China was shown in table 1 [7]. The functions described in the table are based on the domestic oil and gas field mining technology and field experience, which is more in line with the domestic engineering personnel's usage habits.

| Function                  | Petro-Tech | PCS4000 | HC100 | WEATHFORD |
|---------------------------|------------|---------|-------|------------|
| Time cycle control        | YES        | YES     | YES   | YES        |
| Pressure control          | YES        | YES     | YES   | YES        |
| Temporary change control  | YES        | YES     | YES   | YES        |
| control process           |            |         |       |            |
| Electric quantity display | YES        | YES     | YES   | YES        |
| Set well name             | YES        | YES     | YES   | YES        |
| Extracting data           | YES        | NO      | YES   | YES        |
| Data acquisition time     | NO         | NO      | YES   | NO         |
| setting                   |            |         |       |            |
| Abnormal remote alarm     | NO         | NO      | YES   | NO         |
| of pressure               |            |         |       |            |
| Remote real-time data     | NO         | NO      | YES   | NO         |
| query                     |            |         |       |            |
| Remote control and stop   | NO         | NO      | YES   | NO         |
| Short message             | NO         | NO      | YES   | NO         |
| transmission of           |            |         |       |            |
| continuous data           |            |         |       |            |
| Message setting control   | NO         | NO      | YES   | NO         |
| parameters                |            |         |       |            |
| Remote temporary change   | NO         | NO      | YES   | NO         |
| process                   |            |         |       |            |
| Transmission of data      | NO         | NO      | YES   | NO         |
| before open well          |            |         |       |            |
| Data curve playback       | NO         | NO      | YES   | NO         |
| Open well data curve      | NO         | NO      | YES   | NO         |
| replay                    |            |         |       |            |

Petro-Tech and PCS4000 controller have pressure control function, but the use of complicated process, can not be used in the gas field. The WEATHFORD controller has a data extraction function, but by the 485 communication interface for data extraction, needs professional IPC. WEATHFORD controller is connected through RS485 communication protocol, and the data extraction process is complicated and high cost.

The areas between wells and wells is far apart, which leads to wiring problems, so wireless communication mode is used. At this stage, a variety of wireless communication technology development has been used including ZigBee, Bluetooth, wireless LAN (Wifi) (Bluetooth), GPRS/GSM wireless technology. The wireless technology each have their own characteristics, for each industry control system different communication requirements of the corresponding application of wireless communication technology of wireless communication, as shown in table 2 [8-10].
Table 2. Comparison of wireless communication technology.

| Wireless technical standards | ZigBee/802.15.4 | Bluetooth | Wifi/802.11b | GSM/GPRS |
|------------------------------|-----------------|-----------|--------------|----------|
| System resource requirements | 4KB-32KB        | >250KB    | >1MB         | >16MB    |
| Power waste                  | Low             | Common    | Common       | High     |
| Battery life                 | 100-1000+       | 1-7       | 1-5          | 1-7      |
| The number of nodes in local network | 255/65000+ | 7         | 30           | 1000+    |
| Transmission rate (Kbps)     | 20-250          | 1000      | 11000+       | 64-128   |
| Communication distance       | 1-75+           | 1-10+     | 1-100        | 1000+    |
| Advantage                    | Reliability, low cost, low power consumption | Low cost and easy to operate | High speed and adaptability | Good transmission quality and large coverage range |
| Application scope            | Wireless detection and control | For short distance data transmission | A lot of data transmission, such as Web access, multimedia video, etc. | Voice and data can be transmitted |

The gas control system of the multi site distribution in gobi desert without person, and no power grid and communication network. Besides, the distance between wells and control center is more than 40 kilometers, which puts forward the requirements of higher signal quality for wireless transmission and coverage, so the use of GSM/GPRS wireless SMS remote control.

3. The composition and function of the control system

According to the characteristics of the function of the control system and the advantages and disadvantages of domestic gas production process with reference to foreign wells, the gas drainage automatic control system is divided into the following six main functional modules: gas pressure control module, time cycle control module, U disk read data module, process control module, note long-distance control real-time query module, data playback module curve.

4. Design for low power functional modules

USB reads the data the function of power consumption more than 100mA, which was pointed out to control separately. Send power when need to read data. Storage time interval can be set. The data was stored in the memory, and the new data is saved after the full coverage of old data. After insert a U disk, put forward the data firstly and write in U disk in the CSV format [11, 12]. The standby mode of message transmission module is more than 20mA, so it also needs to be controlled separately. The
data curve playback module uses low power and no backlighting liquid crystal module, which is very low power and displays fine, as shown in figure 1.

![Low power consumption module with low power consumption and no backlighting.](image)

**Figure 1.** Low power consumption module with low power consumption and no backlighting.

5. **Prototype functional test**

First, prototype manufacture and function verification are carried out. The prototype structure includes: cabinet door, LCD panel, control panel, solar panel, U card, solar panel support, control cabinet and galvanized tube, as shown in figure 2. The solar panel through the solar panel bracket is fixed on the top of the main liquid crystal display screen. Control cabinet and control cabinet is located in the upper right side of the body, below the control panel located in the control cabinet body front LCD screen. CPU core board and the functional modules are located between the inside of the control cabinet control cabinet body and pipe connected by U clamp. The galvanized round pipe is vertically driven into the field soil at least 1m, and the height of the main body of the control cabinet is reserved on the ground. The cable body interface, the inlet port and the exhaust pipe port of the main body of the prototype control cabinet were arranged.

![Schematic diagram of the structure of prototype.](image)

(1) cabinet door, (2) liquid crystal display screen, (3) control panel, (4) solar panel, (5) U type card, (6) solar panel support, (7) control cabinet body, (8) galvanized circular tube

**Figure 2.** Schematic diagram of the structure of prototype.
The prototype test is carried out in Sulige gas field wells in 2016 for 30 days of on-site inspection. It was tested on 15 functional items as follows: (1) the time cycle control, differential pressure control, (2) (3) time pressure (4) hybrid control, hybrid control, time pressure (SMS 5) SMS remote control switch (6) wells, set all the SMS remote control parameters, (7) the scene through the LCD screen to view 5 consecutive days of work data playback curve, (8) the scene through the LCD screen to view the last 3 open wells data playback curve, (9) the number of wells according to 20 seconds to record at a time the record for 15 consecutive days, circular coverage, (10) U 30 days of data extraction, CSV format, (11) fault alarm message alarm, alarm information (12) receiving mobile phone SMS settings, switch, (13) 30 minutes before the open wells, Send the field data to the designated cell phone, (14) well name setting, and (15) temporarily change the setting process. All of the above mentioned projects have reached the design requirements.

6. Small batch test
In 2016, the control equipments were installed at 10 wells in Sulige gas field for small batch tests, which mainly verified the long time working stability of all functions and whether the management cost was reduced, as shown in figure 3. After the temperature changes throughout the year, all wells control equipment in function have reached the design requirements, no failure rate is 100%. The number of daily inspection wells was reduced significantly, from every other day to check decreasing to every month check once, and the wells cost is reduced by 80%.

Figure 3. Site installation.

7. Batch test
Sulige Gas Field has installed 20 wells for mass operation test. The field application is till working until now (as shown in figure 4), the equipment runs stably, and the economic benefit is remarkable. U disk data extraction is fast and convenient, and the management cost is reduced by 80%. The number of management wells per person is increased. Because of the accurate control, the time of the switch well is reasonable and the formation pressure is stable, thus the stable production can be achieved.
When the pressure of the gas well is abrupt, the change data will be sent out in the form of short message for the first time, which makes the production management more secure and stable.

![Figure 4. The data curve of one month in a test area.](image)

8. Conclusions
We designed the gas drainage gas recovery automatic control system based on 32 bit singlechip, the daily use of mobile phone can be used as a remote control terminal system. Through note sending and receiving orders gas well can be well controlled and data queried. It has the advantages of convenient use, low cost, no need to design the PC software, free maintenance and upgrade PC software costs. Sulige Gas Field has installed 20 wells for mass operation test. The field application is till working until now, the equipment runs stably, and the economic benefit is remarkable. U disk data extraction is fast and convenient, and the management cost is reduced by 80%. The number of management wells per person is increased.

References
[1] Jia C, Zhang Y and Zhao X 2014 Prospects and challenges to natural gas industry development in China Natural Gas Industry 34(2): 8-18.
[2] Chen G, Lin J, Hu W, Gu X, Du W, Zhang J and Qu C 2018 Characteristics of a crude oil composition and its in situ waxing inhibition behavior Fuel 218: 213-217
[3] Badawy W 2011 Monitoring Remote Site, A New Landscape North American Pipelines 4(5): 9-11
[4] Wang Z, Li Y and Tian N 2011 The application of oil well monitoring technology in oil field automation system China Petroleum and Chemical Standard and Quality 31(6): 242
[5] Li X, Cui K, Shao Y and Duan C 2011 Current status and development trend of foreign oil field automation technology China Petroleum Machinery 39(11): 75-77
[6] Zhu G 2013 Design of remote monitoring system for edge gas well Xi’an Shiyou University
[7] Wang Y 2016 Intelligent Alarming System Based on SMS Dalian University of Technology
[8] Shen Z 2007 SMS/MMS Application in Wireless Remote Monitor System Tianjin University
[9] Li M 2015 Design and Implementation of Monitoring and Control System of Natural Gas Well Station Xi’an Jiao Tong University
[10] Liu A, Liang W and Gu H 2001 The Design of the Low Powered Consume about the Single Microcomputer Electronic Instrumentation Customer 5:16-18
[11] Hu C 2008 The development of embedded USB data acquisition system Hubei University pf Technology
[12] Shao Y 2005 The Application of Low Power Consumption Design of Microcontroller System to Data Acquisition System Marine technology 3:36-40