Design of Automatic Control System for the Using of Gas Wells Production

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Abstract. In this paper, by absorbing the advantages of imported control system and equipment and combining years of field experience and the characteristics of domestic gas well mining technology, a new type of automatic control system and equipment for gas well dewatering was put forward. What’s more, short message communication was used to transmit control instructions and data remotely, and functions including the extraction of gas well data by U disk, the replay of recent gas well data curve and the alarm of gas pressure sudden change were added.

Introduction

With the development of monitoring technology of oil and gas field, an unattended remote monitoring system has appeared[1,2]. 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].

Design of Control System

Communication Mode Selection

Table 1. Comparison of the application range of wired and wireless communication.

| The application range of cable | The features of wireless application range |
|-------------------------------|-------------------------------------------|
| The monitoring area is easy to wire, and the communication circuit is rich | High cost of wiring in monitoring area |
| The monitoring area does not have mobility | The monitored equipment is in the mobile working state |
| The amount of information produced by monitoring is large | Monitoring information data is relatively small |
| Monitoring more frequently | Do not need frequent data acquisition and transmission |

Communication is a bridge remote control terminal and field monitoring unit for data and command transmission. Selection of the appropriate communication mode is the key to realize the reliable remote control. The remote control system for the main means of communication with wired communication and wireless communication in two categories, a signal quality line transmission is high, but the communication line construction and after the daily maintenance cost is high, while the
wireless transmission mode can achieve high transmission quality, and can overcome the problems and defects of wired communication mode [7]. The specific applications of the two modes of communication were compared as shown in Table 1.

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 [8]. The system was described in Figure 1. The functions of each module of the system are as follows: (1) pressure control module: according to the set of well opening pressure value and shut in pressure value, the opening and closing of gas well can be realized. (2) the time loop control module: according to the set value and the time of open well shut in time, realize gas circulation opening and closing, and can temporarily change the value and time of open well shut in time, change the value of this switch only well, the next switch wells recovery cycle value. (3) U disk reads data module: through the USB interface on the control panel, U disk can be used to extract oil well pressure and sleeve pressure data of gas well for nearly 2 months, which can be used as a basis for optimizing gas field development process in the future. (4) short message remote control module: can send pressure control instruction or time cycle control instruction to control gas well switch by short message. (5) SMS remote query module: sending real-time data query instruction or historical data query instruction by SMS, inquiring gas well real-time working data and historical work data. (6) data curve playback module: it can be querying through control panel in LCD display, querying the latest 5 days of oil sleeve pressure change trend chart and the latest 3 open well oil sleeve pressure change trend diagram.

![Figure 1. Module division of automatic control system for gas well drainage and gas production.](image)

The Principle of Control System

As shown in Figure 2, the CPU core board is installed in the gas well control equipment, and the CPU core board is connected with the timer, the sleeve pressure sensor, the oil pressure sensor, the control panel, the liquid crystal display and the control system function module. The in formations well open time, Kansai time or well pressure, shut in pressure were input remotely through the field operation panel or note. The sensor began to set pressure, oil pressure sensor monitoring the wells’ oil pressure and casing pressure data. The timer start time, and the current time value is transmitted to the CPU core board, then CPU core board begin to judge if oil pressure data is in reasonable range, if not within reasonable limits, software alarms, and the alarm mode of using note to send "alarm" to any mobile phone number, mobile phone can be used as a mobile phone to accept. If the data in a reasonable range, the data was storied and draw into curve. When the value reaches the set value, cycle time
control module cycle control actuator wells opening or closing; when the gas pressure reaches the set value, the controller performs control gas pressure control module to open or close.

Figure 2. Composition of automatic control system for gas well drainage and gas production.

The working principle of the control system implementation was shown in Figure 3.

(a) flow chart of pressure control mode          (b) flow chart of time cycle control mode

Figure 3. Flow chart of automatic automatic control system for gas well drainage and gas production.
Design and Selection of Hardware

Well site environment is in the barren uninhabited areas, so the grid components need to work reliably in harsh environments. Besides, the work site must be powered by solar energy battery, to work for 15 consecutive days, so the low power design of hardware is very important.

Selection of Control Components

In the field of automatic control, the most widely used components are PLC, RTU and singlechip. Since the advent of these components, they have been widely applied to various fields in China. PLC (Programmable Logic Controller) programming is convenient and powerful; it can replace traditional relay circuit to complete logic control and sequential control. RTU (Remote Terminal Unit), a remote control system, is mainly used to monitor and control the operating conditions of field signals and industrial equipment [9]. Single chip microcomputer is a kind of microcontroller. It belongs to an important part of microcomputer. It has a series of characteristics such as small volume, strong function and so on. The characteristics of the three products are compared with Table 2. According to the characteristics of the three products are compared with Table 2. According to the characteristics of gas well worksite, RTU and singlechip can be selected. However, RTU has higher investment and management cost than singlechip. Considering the control technology and economic requirements of gas well, singlechip should be selected as a control device.

| Product standard | PLC | RTU | Singlechip |
|------------------|-----|-----|------------|
| Application area | Indoor production line and good environment control | Control of outdoor production equipment | Monitoring and control of indoor and outdoor production equipment |
| Communication ability | The general use of single machine, or the use of this series of products, and the communication between other products is more troublesome | With a general communication protocol and communication with the central control room in a wireless way. It can support the wireless communication equipment very well. | With a general communication protocol, it can support wireless communication devices well |
| Working temperature: | 0℃~55℃ | Working temperature: -40℃~75℃ | Working temperature: -40℃~85℃ |
| Storage temperature: | -40℃~70℃ | Storage temperature: -40℃~85℃ | Storage temperature: -40℃~85℃ |
| Relative humidity: | 5%~95% | Relative humidity: 5%~95% | Relative humidity: 5%~95% |

Low Power Design of CPU Core Board

The 32 bit singlechip was chosen as the core board of CPU, which has low working frequency and low power consumption. Besides the necessary I/O, data port and communication port, all other functions are completely shut down, which ensures the lowest consumption of hardware circuit. Singlechip low working frequency, low speed, multi task, in order to guarantee a low rate under the condition of each task can be ready to scan, you must make full use of 32 bit singlechip DMA data transmission function, all peripherals are using DMA data transmission and receiving data, all of the functions to control the execution time within 500 microseconds to save the calculation time of [10].

The operational amplifier selects the rail to rail low power amplifier. Considering the non grid interference in the field, the sensor uses the voltage output low power and the amplifier to collect the voltage signal to ensure that the power consumption of the data acquisition does not exceed 1mA.

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]. 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.

**Low Power Design of Power Supply**

The precision of sampling is guaranteed by using an external precision reference source, and a low power consumption reference is a necessary choice. The reference source used in this paper is low in working current and can output a stable 2.5V reference source with low power rail to rail amplifier.

**Conclusion**

(1) The design of the gas drainage gas recovery automatic control system is according to the process characteristics and field experience of domestic oil and gas exploration, adding data curve playback and U disk data extraction function, which is more in line with site engineering usage. The system hardware adopts low power design, which can withstand on-site harsh operating conditions. The drainage gas recovery automatic control device can realize all the design function, and reduce the management cost of about 80% through the final field test.

(3) Although the design of the gas drainage gas recovery automatic control system eliminates the maintenance and upgrade of PC software costs, but data query is not intuitive through the mobile phone. If the note transmission data is imported into the EXCEL software for further processing, the next step of mobile phone client control APP implementation can directly read the message data curve drawing.

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