The Development and Application of Remote Monitoring System for Oil Well Working Condition with Mobile Phone Module

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Abstract. Some pumping wells are remote and distributed, and it is difficult to find problems such as temporary power outages, fault shutdowns, and belt burning, which cause untimely processing, which seriously affects the rate of well opening and reduces crude oil recovery. In order to effectively monitor the operating conditions of pumping units, mobile phone remote monitoring systems have been developed. The system consists of a remote control module, a power supply module, a wireless transmission module, and a mobile phone terminal. It can facilitate front-line employees to quickly monitor oil well operating parameters, detect pumping unit failures in a timely manner, reduce hidden safety hazards, avoid pollution, and provide a powerful technical support for green mine construction.

1. Introduction
The main equipment for producing oil in an oil field is a pumping unit. During the normal operation of the pumping unit, various types of faults such as abnormal power outages, shutdowns, and belt burnouts often cause well shutdowns. Due to the remoteness and scattered distribution of oil wells, lag problems, which manual shutdowns are used to detect faulty shutdowns, are common. Some oil wells are inconsistent with the power supply line of the duty room, and the phenomenon of "power inside the station and no power outside the station" often occurs, which leads to the failure of power wells to be discovered in a timely manner. For low-efficiency wells that do not produce power and have high output costs, intermittent open are usually adopted. In order to achieve precise management and reduce the cost of electricity, some wells are opened at bottom and closed at peaks. Frontline employees need to close the well in the early morning, but the staff on duty during this period is tired and prone to safety accidents. At the same time, there is also a delay in stopping the well, which lengthens the time for invalid well opening and increases power consumption. The above problems seriously affected the rate of well opening and reduced the oil recovery rate. Therefore, in order to facilitate the operation of frontline employees, reduce the number of well visits, timely and effectively monitor the conditions of oil wells, and improve the level of field management, a mobile remote monitoring system was developed.¹

2. Mobile Phone Remote Monitoring System for Oil Well Conditions
The oil well condition mobile phone remote monitoring system is composed of a remote control module, a power supply module, a relay module, and a mobile phone terminal. It can timely detect oil well failures, shut down wells at regular intervals, and perform real-time query of operating parameters.
2.1 Remote Control Integration Module
By installing a data acquisition module, central processing unit, and wireless transceiver module in the pumping unit well, the real-time wireless remote transmission of the operating parameters of scattered and remote wells is shown in Figure 1.

![Remote control integration module](image1.jpg)

**Figure 1.** Remote control integration module

The remote control integrated module is composed of Hall sensor, proximity switch, monitoring alarm and central processing unit. It is mainly used to collect the running status of the belt, the execution module and the distribution box. Through the central processing unit and wireless transceiver module, the handheld control terminal is queried. 

2.2 Power Supply Module
The uninterruptible power supply module and voltage stabilization module can realize three modes: monitoring power supply mode, wireless transceiver module power supply mode, and intermittent power supply mode. The system power supply diagram is shown in Figure 2.

![Frame diagram of stable power source](image2.jpg)

**Figure 2.** Frame diagram of stable power source

2.2.1 The power transformer transforms the AC voltage into the AC voltage required by the rectifier circuit and transmits it to the rectifier circuit. The magnitude of the secondary voltage determines the transformer ratio. The input AC voltage is 220V ± 10%, 50Hz. Please See Figure 3 and 4.

![Automatic voltage regulator](image3.jpg)

**Figure 3.** Automatic voltage regulator

![Power cells](image4.jpg)

**Figure 4.** Power cells
2.2.2 Utilizing the unidirectional conductivity of the diode, the main role of the rectifier circuit converts a sinusoidal AC voltage into a DC pulsating voltage, as shown in Figure 5.

![Figure 5. Rectifier unit circuit diagram](image)

2.2.3 Utilizing the characteristics that the voltage across the capacitor cannot be abruptly changed and the current flowing through the inductor cannot be abruptly changed, the filter circuit filters out the ripple from the ripple voltage, so that the output voltage becomes a relatively smooth DC voltage.

2.2.4 After rectification and filtering, AC power can obtain smooth and stable DC voltage. When the grid voltage fluctuates and the load changes, the output voltage also changes. The role of the voltage stabilization circuit is to stabilize the output voltage at 12V under these two conditions, as shown in Figure 6.

![Figure 6. AC/DC converter power supply](image)  ![Figure 7. Relay module](image)

2.3 Relay Module

By installing 220V relay module, 12V relay module and time relay, the equipment can be shut down regularly and monitored and alarmed, as shown in Figure 7.

2.3.1 Motor running relay

The motor running relay consists of an iron core, a coil, an armature, and a contact spring. When a voltage is applied to the coil, a current will flow, thereby generating an electromagnetic effect, and the armature will be attracted to the core by the force of the spring against the force of the spring, and the movable contact of the armature and the normally open contact will be attracted. When the coil is de-energized, the electromagnetic attraction force disappears, and the armature will return to the original position under the reaction of the spring, so that the movable contact and the normally closed contact are attracted. This pulls in and releases to achieve conduction and cut-off in the circuit.

2.3.2 Open time relay

When the coil is energized, the time-delayed normally-closed contact is opened with a delay, and the time-delayed normally-open contact is closed with a delay. When the coil is de-energized, the time-delayed normally closed contact immediately resumes closing, and the time-delayed normally open contact immediately resumes opening. That is, the time starts when the power is turned on, when the set time is reached, the state of the contact is switched, and the state of the contact is restored immediately after the power is turned off. That is, the power-on delay, the power-off does not delay,
see Figure 8.

![Time relay](image1)

**Figure 8.** Time relay

2.4 Mobile Terminal

The GSM module is installed to detect the wireless remote control to realize remote inquiry and reception of the on-site working status of the pumping unit.

GSM short message controller is a kind of network equipment based on SMS service. It can support users to edit short messages through mobile phones and send short message information instructions to remotely control electrical equipment to work [3]. Therefore, it can achieve the automatic control in unattended place. The relay in the wireless signal control module is mainly used to achieve remote operation requirements. As a wireless remote control device, the SMS controller uses SMS services to make it available without local restrictions. In general, as long as there is a mobile phone signal, the SMS controller can communicate and work, as shown in Figure 9.

![Block diagram of remote control system](image2)

**Figure 9.** Block diagram of remote control system

1. Data acquisition module; 2. Central Processor; 3. Wireless Transceiver module; 4. Control terminal; 5. Motor timing control module; 6. Motor stall alarm; 7. Execution module; 8. Power supply module; 11. Hall sensor; 12. Proximity switch sensor; 13. Monitoring alarm; 41. Main mobile phone terminal; 42. Secondary mobile phone terminal; 51. Relay module; 52. Open time relay; 81. Circuit breaker; 82.12 volt regulated power supply; 83. Uninterruptible power supply module

The working principle of the oil well remote monitoring system: When the power distribution box
is powered off, the internal electronic components of the power distribution box are faulty, or the belt is burned out, the data acquisition module will send the corresponding alarm information to the terminal for alarm, or it can be via mobile terminal Query the working status of the pumping site. When the terminal receives the belt burnout alarm, the central processing unit controls the motor of the pumping unit to stop automatically after 10 seconds. If the running time of the pumping unit motor reaches the set time limit of the open time, the contacts of the open time relay will be automatically opened, the pumping unit motor will stop, or the motor can be controlled by the central processing unit via the mobile phone terminal. The power supply can be stopped by remotely shutting down the power supply module, and then the relay contacts of the open time are disconnected, and the pumping unit motor is stopped. At the same time, after the Hall sensor receives the stall signal of the pumping unit, it transmits the signal to the terminal via the wireless transceiver module for alarm and completes the site monitoring of the pumping unit.

3. Field Applications

3.1 Application of Remote Control Module
Hall sensor, proximity switch sensor, monitoring alarm, belt running status, execution module working status, distribution box working status and other status data are processed by the central processor and wireless transceiver module to realize handheld terminal query, see Figure 10, Figure 11.

3.2 Application of Power Supply Module
The uninterruptible power supply module and voltage stabilization module control the operation of the pumping unit motor via a remote module, which can realize three power supply modes: Mode 1, monitoring power supply mode, the power supply module supplies power to the electronic components in the distribution box, and the device starts normally; Mode 2, the power supply mode of the wireless transceiver module, the power supply module supplies power to the wireless transceiver module, and the wireless transceiver module starts to work; mode three, the intermittent mode, the power supply module supplies power to the intermittent time relay, the relay contact of the intermittent time is closed, and the pump motor starts.

3.3 Application of Circuit Breaker Module
The relay module can realize the timing on / off control of the pumping unit motor. For example, when the terminal receives a belt burnout alarm, the central processing unit controls the time relay to work according to an internal program. The pumping unit motor automatically stops running after a few seconds to prevent the pumping unit motor from idling.

3.4 Data Transmission
Because the remote monitoring system involves the Internet, and the data and control commands of the oil well system are extremely sensitive, the data card uses the China Mobile protocol card to transmit data via SMS, and certain security measures are taken in the main station software, but it is far from enough and needs to be further strengthened.
3.5 Data Analysis
Taking the belt burnout as an example, when the belt burns out, the problem information is transmitted to the central processor through the Hall sensor, and then to the mobile phone terminal through the wireless information template to prompt the alarm. At the same time, the relay controls the motor to stop to avoid the motor idling [7].

3.6 Application of Mobile Terminal
After installing the GSM module, the alarm information received by the mobile phone can be used to send commands through the mobile phone SMS to achieve remote shutdown of the motor, see Figure 12.

![Figure 12. Mobile Terminal Receives information](image)

The mobile phone remote monitoring device for pumping unit working conditions is divided into three modes (the site has a switch):

1. Hall operation monitoring mode: There are alarms for abnormal situations such as pumping unit power on, power failure alarm prompts, electrical faults, cable anti-saw alarm prompts, automatic motor stop alarm prompts (time can be set) after the belt is burned out.

2. Inter-well operation mode: It is suitable for inter-well operation during bottom electricity operation and inter-well operation with insufficient fluid supply. According to the inter-well operation system, remote automatic start and stop can be realized by setting the time(0-99 hours). It also has the function of manual remote start and stop of the well, which is operated through the mobile APP. At the same time, it has the function of alarming for abnormal conditions.

3. Field mode: When the remote monitoring system is overhauled or the monitoring system fails, it can be switched to the field mode without affecting the normal operation of the pumping unit.

Since it was applied in No.2 oil production plant, HUABEI Oilfield in 2017, the mobile phone remote monitoring system for oil well conditions can realize remote monitoring of the operating status of pumping wells via mobile phones. The operation is simple and practical, and effectively avoids the situation that employees frequently operate on-site for intermittent open well, especially to avoid the safety risks of field operations during the early morning hours, reducing labor intensity. The application in the field has a good effect, can effectively monitor the operating parameters of oil wells, timely find faults of pumping units, avoid environmental pollution, achieve fine management, and improve the level of oil well automation management [4].

4. Conclusion
Due to the complexity of oil field conditions, the actual problems of pumping unit production cannot be found in time [8]. The combination of mobile phone terminals and oil well condition monitoring belongs to the category of smart employees. Starting from the actual problems on the site and investing at a lower cost, it effectively solves the difficulties encountered by front-line employees in the production process. The operation of the oil well condition mobile phone remote monitoring system effectively improves the real-time monitoring level of the main operating parameters of the machined wells, so that managers, especially front-line employees, can effectively and quickly grasp the working status of the oil wells. Carrying out refined management for intermittent wells, remotely and regularly shutting down the system reduces energy consumption, and detects faults and shutdowns in a timely manner, which greatly increases the rate of well openings, increases oil well production, avoids the losses caused by faults and shutdowns, and greatly reduces the labor intensity of front line
employees. In order to realize the real unmanned well site, improve the level of oil well production automation and informatization. It provides strong technical support for standardized and efficient production management. [9][10]

5. Reference

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