Research on Downhole Plunger Position and Pressure Temperature Detection of Plunger Gas Lift System

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Abstract: Plunger gas lift utilizes the energy of gas production in the formation. By periodically switching on and off the gas well, the plunger moves up and down in the tubing to discharge the bottom hole fluid. The purpose is to reduce the back pressure on the production layer and increase the gas production of the formation. Power, prolong the production life of the gas well. The plunger gas lift detection is the core part of the plunger gas lift system. Adjusting the working status of the downhole plunger through the detection of downhole plunger position, temperature and pressure has important engineering value for improving the oil recovery efficiency of the gas lift process. In order to promote the development of downhole detection systems for gas lift wells in my country and overcome the difficulties of late start and lack of experience, this article focuses on the development status of the detection of plunger gas lift systems. the paper briefly introduce the composition of the plunger gas lift system, analyze the problems of the plunger arrival position detection and temperature and pressure detection in the gas lift detection system, and then analyze the current status of the plunger position monitoring of the plunger gas lift downhole. A review is made, followed by a review of the current status of domestic temperature and pressure monitoring systems for plunger gas lift wells. The review found that the detection of plunger position in my country is still at a relatively weak stage, and direct measurement cannot be achieved; however, there have been breakthroughs in the detection of temperature and pressure, especially in the fields of pressure and temperature detection, storage and wireless transmission. breakthrough. The analysis believes that the detection of downhole parameters of plunger gas lift should be developed in the direction of the integration of well digital control and data acquisition system and digital measure adjustment.

1. introduction
Plunger gas lift utilizes the energy of gas production in the formation. By periodically switching on and off the gas well, the plunger moves up and down in the tubing to discharge the bottom hole fluid. The purpose is to reduce the back pressure on the production layer and increase the gas production of the formation. Power, prolong the production life of gas wells [1,2]. The plunger gas lift drainage gas...
recovery technology has the advantages of low equipment investment, long service life, low installation and maintenance costs, and high lifting efficiency. This technology has been widely used in the later stages of production in domestic and foreign oil and gas fields. It is a low-yield gas well for drainage gas recovery [3,4]. In the plunger gas lift system, the measurement of the plunger's reach position and pressure and temperature is the core of the entire detection system. The data measured by the early detection system is transmitted to the surface via cable, and then data such as downhole pressure, temperature and plunger position are manually checked. The pressure and temperature data in the plunger are mainly obtained through the storage pressure gauge. The pressure and temperature data in the well cannot be obtained quickly and timely. With the rapid development of digital automation technology, the temperature, pressure and plunger position have Great changes have taken place in detection, storage, and transmission methods.

2. Plunger gas lift well system
The plunger logging system and control technology combine well logging with the plunger gas lift process, and use downhole logging in the shut-in and recompression stage during the gas lift process operation to measure bottom hole temperature, bottom hole flow pressure and liquid production flow information. The system can store the measurement data at the bottom of the well, and then transmit it to the wellhead controller through the wireless communication scheme when it reaches the uplink stage, so as to realize the safe collection of logging data and improve the accuracy and diversity of data collection [5]. Table 1 shows the composition of the plunger gas lift system, which is mainly divided into electrical monitoring modules and mechanical structure modules. Figure 1 is a schematic diagram of the plunger gas lift system.

| Table 1 Composition of plunger gas lift system |
|-----------------------------------------------|
| component | Function and function introduction |
|----------|----------------------------------|
| Plunger  | The fault pushes the downhole fluid to drain out of the wellhead to realize the normal operation of gas lift. There are three commonly used plunger types: vane plunger, brush plunger and rod plunger. |
| Plunger trap | It is used to fix the plunger to prevent falling during the maintenance, installation, and debugging of the gas lift system. |
| Plunger stopper | Located at the bottom of the gas well tubing, it acts as a buffer zone during the plunger's falling process to slow down the plunger's falling speed and protect the plunger and bottom hole facilities. |
| Gas lift controller | The plunger gas lift control unit collects the data of each sub-module, analyzes and processes the normal operation of the gas lift. |
| Pneumatic film regulating valve | The execution unit of the gas lift system realizes the circulation and cut-off operation of the entire pipeline. |
| Pressure Sensor | The data acquisition unit of the gas lift system is mainly responsible for detecting the wellhead casing pressure value. |
| Plunger sensor | The plunger reaches the signal detection device. |

The sensor is usually designed to be placed below the catcher. The data transmission end of the sensor is connected to the control end of the plunger gas lift, and the on-site drainage status is transmitted to the remote terminal through a remote communication device. However, there are still some problems in the monitoring of plunger gas lift wells in my country. They are mainly divided into two parts. The first is the detection of the position of the plunger, and the second is the temperature and pressure detection defects in the detection system, as shown below [6].

1. The domestic plunger arrival monitoring sensor cannot be provided independently. This has the problem of detecting the measuring point of the plunger, and it is impossible to directly monitor the movement state of the plunger. Most domestically, a monitoring device is installed inside the pipeline to measure the arrival point of the plunger, but this monitoring method has the limitations of inaccurate measurement, difficult to calibrate, and easy to damage.

2. The existing pressure pulse propagation method has certain defects. Downhole test signals are
transmitted through pulses, that is, transmitted from the gas medium in the pipe to the wellhead, but the transmission method has many shortcomings: 1) Inter-symbol interference. This high-frequency emission characteristic between the tubing joints causes the impact time of the drill string pulse to last up to 100 milliseconds; 2) noise interference. During the process of gas production, the noise ratio generated by the movement of the multiphase flow can over change the signal-to-noise ratio, thereby affecting the channel transmission; 3) Acoustic attenuation. When the sound wave diffuses in a spherical manner, it will be affected by the medium and obstacles, so that the energy is absorbed by the medium or obstacles and converted into other forms of energy; 4) There are few measurement parameters.

3. Overview of plunger position monitoring downhole for plunger gas lift
In the plunger gas lift well system, the plunger plays the role of isolating the downhole liquid and the downhole gas during the energy storage and lifting process. Therefore, the detection of the arrival position of the plunger is the key to realize the effective safety control of the plunger gas lift. Generally, two methods are used to measure the position of the plunger. One is to install a sensor in the relevant internal position to measure whether the plunger passes through the place; the other is to install a sensor on the ground to detect the plunger whether it collides with the inner wall of the tubing.

3.1. Overview of indirect detection methods
The indirect detection method is to measure the changes of physical variables caused by the upward movement of the plunger in the tubing, such as downhole fluid, plunger, and expanding gas. The design of the indirect measurement method requires the equipment to be capable of detecting the status of the plunger reaching the wellhead. The most effective indirect measurement method is the vibration signal measurement method. This is mainly due to the continuous collision of the plunger with the inner wall of the tubing during the upward process, causing the oscillation of the internal fluid accumulation. Vibration caused by the tubing. Therefore, the arrival of the plunger can be effectively judged by detecting the vibration intensity. The measurement of vibration signal is divided into acceleration measurement, speed measurement, and displacement measurement. Table 3 shows the indirect measurement method of vibration intensity.

| Measurement technology | Basic features/measurement principle |
|------------------------|-------------------------------------|
| speed sensor           | 1. Divided into linear velocity measurement and angular velocity measurement; 2. The displacement speed of the speed sensor cannot be too high |
| Accelerometer          | 1. Principle classification: piezoelectric, capacitive, inductive, piezoresistive, tunnel current, resonance; 2. Function classification: tilt detection, motion detection, positioning detection, vibration detection, vibration detection and free fall detection; 3. Measurement classification: single direction measurement, multi-dimensional measurement; 4. Usually used for high frequency vibration detection. |
| Motion detector        | 1. After the speed sensor is detected, the data is calculated by an integral calculation to obtain the displacement data 2. Acceleration sensor, the speed and displacement data can be obtained after the data is integrated twice |

There are many domestic researches on indirect measurement. After comparing and analyzing the plunger arrival measurement methods, Xiang Wei[7] designed a research plan based on the acceleration sensor to detect the plunger arrival signal. The program studies the signal characteristics of acceleration, velocity and displacement in vibration work, and selects the best judgment parameters in tubing vibration. Through the indoor impact experiment, the signal characteristics of the vibration
signal in the various dimensions of the vibration signal are analyzed when the vibration source is gradually approaching, and the feasibility of detecting the arrival of the plunger based on the acceleration sensor is proved.

Figure 1 Storage plunger recording instrument

3.2. Summary of Direct Detection Method

Table 2 and Table 3 are the methods used for direct measurement and indirect measurement, respectively. Among them, the direct measurement methods mainly include infrared photoelectric method, ultrasonic distance measurement method and proximity switch detection technology method.

Table 3 Introduction to measurement technology of direct measurement method

| Measurement technology | Basic features/measurement principle |
|------------------------|--------------------------------------|
| Infrared photoelectric method | Infrared photoelectric technology is adopted, and the infrared pair tube is generally used to detect the position of close objects. |
| Ultrasonic Ranging Method | 1. Composed of transmitter, receiver, microcontroller, and communication unit. 2. Ultrasonic detection method is mostly used to measure the position of objects; 3. Principle: Measure the time t of the sound wave from the transmitter to the receiving transducer, and calculate the distance between the measured object and the measuring device based on the relationship that the measured distance is equal to the time t multiplied by the sound wave velocity v. |
| Proximity switch detection technology method | 1. Using electromagnetic working principle to convert non-electricity signal or electromagnetic quantity into electric signal, so as to realize position detection; 2. Proximity switch classification: inductive proximity switch, capacitive proximity switch, magnetic proximity switch. 3. Detection index: standard detection object, working distance, motion hysteresis, conduction voltage drop and leakage current, working voltage, working current. |

Domestically, there are also attempts to design independently in the field of plunger arrival detection. For example, Changqing Oilfield\(^8\) proposed an intelligent capture plunger device, which uses automatic capture and release of the plunger to improve the operation of the plunger and increase the production efficiency of gas wells. The device is designed with plunger anti-collision device, plunger catcher and control system. The plunger arrival sensor is composed of a magnetic sensor group, a magnetic sensor controller, a microprocessor, a communication module, and a logic output module. The actuator is the core control center of the entire trap. The control center receives the signal and sends out the trap capture signal. The actuator includes a microprocessor and a motor control chip. PetroChina\(^9\) disclosed a plunger arrival sensor, which is designed with a signal terminal, a common terminal, a parameter acquisition unit, a power supply terminal, a power supply, a parameter acquisition unit, and a circuit board. The basic working principle is: the parameter acquisition unit can collect the operating parameters of the plunger according to the change of the magnetic field intensity around the sensor, and transmit the operating parameters to the signal terminal, and then transmit the operating parameters to the controller from the signal terminal. And the collected operating parameters include whether the plunger reaches the wellhead, the length of the plunger hovering at the wellhead,
and the time when the plunger falls. Compared with the existing plunger reaching the sensor, more operating parameters are detected, and when the plunger reaches the sensor, there is no need to replace the complete set of devices, and the cost is lower. Therefore, the working efficiency of the plunger to the sensor is improved and the cost is reduced.

Foreign countries have a monopoly on the detection equipment that reaches the sensor \(^{[10]}\). For example, the arrival detection devices produced by PCS (Production Control Services Ltd) in the United States and Compass (Compass Oil and Gas Solution Ltd) in Canada are the main domestic equipment providers\(^{[11]}\). The new 3DS0 plunger arrival sensor developed by PCS in the United States is widely used in field production. The sensor has a power of 3-36 watts and is installed on the surface of the plunger pump. It can accurately detect whether the plunger is reached and activate the controller to the corresponding mode to realize the production and shutdown of the natural gas well. The sensor has the advantages of working in a highly complex environment, long life, high detection accuracy, automation and strong anti-interference ability.

On the whole, foreign countries have a significant lead in the detection technology of plunger arrival, and foreign plunger sensors are automated, integrating digital control and data acquisition systems as well as digital measures. The domestic plunger arrival monitoring sensor is still at a relatively weak stage, and the problem of the detection of the plunger measuring point is still very serious, and it is impossible to directly monitor the movement state of the plunger. Most domestically, a monitoring device is installed inside the pipeline to measure the arrival point of the plunger. This monitoring method has the limitations of inaccurate measurement, difficult to calibrate, and easy to damage. There are also institutions and units that directly design the arrival sensor. Although the accuracy of the test is still weaker than that of foreign countries, this has important practical significance for breaking foreign monopolies.

4. Current Status of Research on Downhole Pressure and Temperature Detection of Plunger Gas Lift

In the plunger gas lift system, the measurement of temperature and pressure is also one of the cores of the entire system. The measurement of temperature and pressure is developing in the direction of high precision and high resolution. The Southwest Oil and Gas Field\(^{[12]}\) carried out the use of high-precision and high-resolution electronic pressure gauges to measure temperature and pressure. The specific method is: using electronic pressure gauges to make temperature-mixed pressure profiles under different systems, and according to the pressure-temperature profile change the law, identify the gas flow status, analyze the problems in the gas lift well, adjust the working status in real time, and perform real-time detection of temperature and pressure. Then analyze the existing problems of gas lift wells, and quickly determine a reasonable working system after system adjustment.

Wuhan University\(^{[13]}\) Wang Hongchen designed an anti-interference tubing pressure sensor when using active detection of the plunger position. The pressure sensor is equipped with a sonic air gun with a pressure pulse generator, and uses a digital data acquisition system to measure each sonic liquid. The round-trip time of the surface test, the one-way time is obtained, and then multiplied by the speed of sound to determine the depth of the plunger or the liquid surface (after the plunger enters the liquid). However, the sound wave is greatly interfered by noise, and the resolution is unstable. PetroChina\(^{[14]}\) discloses a plunger test system, which includes a plunger body of a downhole temperature and pressure gauge for measuring and storing downhole temperature and downhole pressure. The system includes temperature, temperature and pressure measurement components, temperature sensors and pressure sensors are connected to the signal adjustment circuit, the adjustment circuit is connected to the digital-to-analog signal converter, the digital-to-analog signal device is connected to the digital signal processing, and the digital signal processor is connected to the signal adjustment circuit. The storage chip is connected. During the up and down stroke of the test plunger, the downhole temperature and pressure gauge on it measures the downhole pressure and temperature, as well as the pressure and temperature changes at different positions. The plunger test system can collect downhole temperature and pressure data, and match the appropriate structure type of gas lift
plunger for the plunger gas lift oil production well based on the data to improve oil production efficiency.

![Figure 2 Sectional view of the plunger test system](image1)

![Figure 3 Schematic diagram of the active monitoring](image2)

Traditional pressure and temperature measurement are collected by loading a storage pressure gauge, and then transmitted by cable. This transmission method cannot achieve real-time transmission and cannot achieve precise control. Guizhou Aerospace Kaishan Petroleum Instrument Co., Ltd. took the real-time acquisition of pressure and temperature data in the well as its starting point, and designed and developed related products for wireless transmission of data such as plunger well pressure and temperature\[15,16\]. the system set up a ground control instrument at the wellhead, connect the ground control instrument to the wellhead antenna assembly, and set a downhole pressure gauge downhole; the ground control instrument periodically scans through the wellhead antenna assembly and tries to establish wireless communication with the downhole pressure gauge; when the downhole pressure gauge is in gas energy When pushing down to the wellhead blowout preventer, the ground control instrument will establish a wireless connection with the downhole pressure gauge through the wellhead antenna assembly, thereby wirelessly transmitting the pressure and temperature test data in one operation cycle to the ground control instrument. Also designed a low-power wireless communication system for plunger pressure gauges. The downhole pressure gauge in the system includes a microprocessor and a disposable battery connected to the microprocessor, a clock module, a wireless communication module, an antenna assembly, and The acquisition module, the acquisition module is connected with sensors, and the sensors include a pressure sensor and a temperature sensor. It integrates multiple functions such as gas lift drainage and gas recovery, wellbore pressure and temperature collection, and automatic data uploading into the plunger. At the same time, it completes a long-term continuous work task with a limited disposable battery capacity.

The conventional pressure sensor is transmitted to the controller through the cable, which is greatly affected by the outside world. PetroChina\[17\]designed a gas-lift plunger downhole pressure data wireless transmission system for gas wells. The downhole pressure detection device includes a pressure monitoring module and a data transmission module. The wireless data readback instrument includes a data readback module and a data transmission module. The detection system can realize wireless readback of downhole pressure data without a communication cable, and can perform long-term downhole detection of the downhole pressure of natural gas wells. The remote transmission and remote control of pressure and temperature is a new development direction. CNPC designed a plunger gas lift controller and method with remote transmission and remote control function\[18\]. The controller has an integrated pressure gauge, and the casing gas is directly connected to the pressure sensor through a dedicated gas source pipeline. This method uses a high-pressure gas source. The pipeline transmits the casing pressure to the controller pressure sensor position, the oil pressure plunger arrival and other related parameters are transmitted to the junction box position through a limited transmission, all the data enters the controller core component main board, the data is analyzed and processed, and automatically optimized and formed In this well plunger operating system, the parameters recorded by the controller are transmitted to the server through the transmission antenna, and then the remote control software is installed on the client to debug the plunger operating system to make the plunger run to the maximum. Excellent state. This remote transmission and remote control
method realizes the timely collection, storage and wireless transmission of pressure and temperature data in the well. The user can view the recent temperature and pressure data of a certain or multiple plunger wells on the control center computer.

Figure 4 Plunger gas lift controller and method with remote transmission and remote control function

To sum up, the design of the temperature and pressure monitoring system for plunger gas lift wells in my country is mainly carried out from the three most important aspects of data acquisition, storage and transmission after the temperature and pressure are collected. The analysis shows that the transmission of downhole pressure and temperature after measurement in my country mainly uses cable transmission. There have been great breakthroughs in the real-time transmission of pressure and temperature and wireless communication transmission, but it is still a breakthrough worthy of the high efficiency and long-term transmission. Focus on it. And there is little research on how to measure temperature and pressure with higher precision and higher resolution in China.

5. Conclusion
This article introduces the composition of the plunger gas lift system, analyzes the problems of the plunger arrival position detection and temperature and pressure detection in the gas lift detection system, and then summarizes the current status of the plunger position monitoring in the downhole plunger gas lift. Secondly, the current situation of the domestic temperature and pressure monitoring system for plunger gas lift wells is reviewed.

(1) This article takes the plunger gas lift well detection system as the starting point, introduces the composition of the plunger gas lift system, and analyzes the problems existing in the detection of the plunger's arrival position and the temperature and pressure detection in the gas lift detection system. The analysis found that the domestic plunger arrival monitoring sensor cannot be provided independently. It is usually measured with a monitoring device installed inside the pipeline, but it has the limitations of inaccurate measurement, difficult to calibrate and easy to damage. The temperature and pressure detection method adopts the pressure pulse propagation method, and the transmission method has defects such as inter-symbol interference, noise interference, sound wave attenuation, and few measurement parameters.

(2) Plunger gas lift downhole plunger position monitoring has two methods: direct measurement and indirect measurement. Direct measurement includes infrared photoelectric method, ultrasonic distance measurement method and proximity switch detection technology method. The most commonly used indirect measurement method is vibration intensity measurement. The measurement of vibration signal is divided into acceleration measurement, velocity measurement, and displacement measurement. The detection technology of foreign plungers is greatly ahead of the domestic ones, and the degree of automation is high. It integrates digital control with data acquisition systems and digital measures. The domestic plunger arrival monitoring sensor is still at a relatively weak stage, but related companies and units have made attempts to directly design the arrival sensor. Although the test accuracy is still weaker than that of foreign countries, this has important practical significance for breaking foreign monopolies.

(3) The domestic temperature and pressure monitoring system design for plunger gas lift wells is mainly carried out from the three most important aspects of data collection, storage and transmission.
after the temperature and pressure are collected. The transmission after downhole pressure and temperature measurement is still mainly by cable transmission, but it is still a key point worthy of breakthrough for the high efficiency and long-term transmission. The measurement of temperature and pressure with higher accuracy and resolution is still relatively weak.

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