

# Straight-Reading Electric Measurement Technique for Polymer Flooding Injection Wells

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**Keywords:** Polymer flooding; flow test; test and adjust simultaneously; mechatronic control technology.

**Abstract:** In Daqing oilfield, the polymer flooding wells with more than 3 layers have reached 50%. For conventional steel wire fishing and layer flow test method, the working is cumbersome in operation, heavy in workload and long in measuring and adjusting time. To this problem conducted a polymer flooding injection straight-reading electric measuring technology research. With advanced mechatronic control technology, using test and adjust simultaneously methods, real-time monitoring of parameters such as docking status, flow rate, pressure, and temperature during the polymer flooding injection wells layer flow test. The result shows that 3-5 layer single-well measurement efficiency has improved by more than 2 times. Polymer flooding injection straight-reading electric measuring technology achieved the goal of completing the multi-layer flow deploy with once down the well, test efficiency and test pass rate has significantly improved and has a good promotion and application prospects.

## 1 INTRODUCTION

Daqing oilfield is a large-scale deposited sand oil field, belongs to the heterogeneous reservoir sandstone reservoir, with the deepening of the polymer flooding, the displacement gradually shift to low permeability layers, however, there are many vertical layers in the oil layer, strong heterogeneity, serious inter-layer interference, and difficulty in stratified testing[1-3]. Polymer flooding injection Wells from 2007 to 2017 increase at an annual rate of 1000, the test workload increased by more than 4000 Wells, in order to ensure the normal injection, need to increase the test equipment and labor costs about 10 million yuan each year, at the same time, the traditional testing technology uses matching method, need to repeatedly fishing plugs to replace throttling cores, labor intensity is bigger but test efficiency is lower[4-5]. In order to improve the test efficiency and the injection rate, the technology of straight-reading electric measurement for polymer flooding is developed[6].

## 2 COLUMN SELECTION

In recent years, Daqing oilfield development various polymer flooding dispensation technologies, such as cylindrical structure, annular decompression groove, spindle pole, improved spindle pole and streamlined step-down, in order to determine the best injection process as the base string of polymer flooding straight-reading electric measurement, comparing the five dispensing columns used in the oilfield.

### 2.1 Indoor Comparison Evaluation

First of all, five in-house dispensing tools were tested for indoor fishing and hydraulic performance evaluation, the results shows: Streamlined step-down dispensing tool has the highest fishing success rate, the highest throttling pressure difference at the same flow rate and the lowest sticking loss rate.

### 2.2 Field Comparison and Evaluation

For comprehensive contrast polymer injection tools, has conducted field comparison of hydraulic characteristics, mainly selected the larger application streamlined step-down groove, cone spindle pole,

spindle pole three kinds of tools. When the flow rate is  $60\text{m}^3/\text{d}$ , the cone spindle pole has lower throttling pressure difference than streamlined step-down groove. And the spindle (4 balls/140mm) is 52mm longer than the streamlined step-down groove (8 slots/88mm), but the throttle pressure difference is 0.21MPa lower than streamlined step-down groove. By contrast, the streamlined step-down groove has good performance .

In comparison of field sticking loss rate, cone spindle pole have a higher rate of sticking loss, and there is a linear relationship between the sticking loss and the flow rate of the spindle pole, the sticking loss increases with the increase of the flow rate. The sticking loss of the streamlined step-down groove increases gradually with the increase of flow, and finally tends to be stable .

Considering indoor and field contrast, streamlined step-down groove structure points injection tools with high throttle pressure difference, low viscosity loss, measurement technology is fully compatible with water injection, the column the technical advantages such as can simultaneously meet the need for flooding of different injection media.

### 2.3 Column Setting

Comparing the test of polymer flooding points injection column, select streamlined step-down groove structure corresponds to the integration points separate process for polymer flooding injection Wells straight-reading of electric measurement technology of the column, the process is based on the interval property selection pressure regulator or molecular weight regulator. In low permeability reservoirs, Low molecular weight regulators are used to reduce polymer molecular weight, increase oil layer degree of use and volume of exposure[7-9].

The whole process integration of separate injection technology field application of more than 6000 Wells, after layered injection, compared with normal polymer separate injection Wells, Oil layer use are improved, using layer increased from 68.2% to 73.9%, the use of thickness ratio from 73.9% to 80.9%. At the same time, the pipe column is compatible with the water, it also can meet the requirements of subsequent water flooding, and reduces the cost.

## 3 POLYMER FLOODING WELL STRAIGHT-READING ELECTRIC MEASUREMENT TECHNOLOGY

Relying on the integration of the whole process of technology column, designed the polymer flooding straight-reading electric measurement technology, mainly including ground control system, straight-reading electric measuring instrument, adjustable plug, cable winch system(as shown in figure 1).

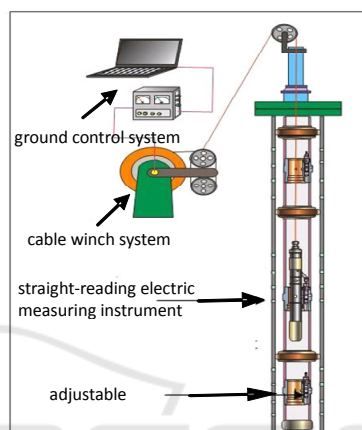


Figure 1: Structure diagram of polymer flooding well straight-reading electric measurement technology.

### 3.1 Process Principle

First, in polymer flooding injection wells into the whole process of injection column, according to the requirement of the solution set the polymer flooding adjustable pressure plug or adjustable molecular plug under the corresponding layer, and then uses the steel cable with straight- reading meter to the purpose layer, then docking with adjustable pressure plug or adjustable molecular plug, through adjusting the plug slot number or nozzle to control the single flow rate, molecular weight, until meet the requirements of injection allocation scheme, which can realize the continuous adjustable, quantitative control and real-time monitoring, to improve the efficiency of the layered testing.

### 3.2 Control System

The control system is composed of computer and power supply system. The whole system has functions such as flow protection, power supply conversion, cable voltage compensation, signal

processing, data acquisition and data communication. When applications, ground control part have a communication signals, to complete the collection of flow, temperature and pressure, and real-time display and control the down hole working conditions of the instruments, which can realize data admission control, data storage, report output and parameters tuning, etc. (as shown in figure 2).

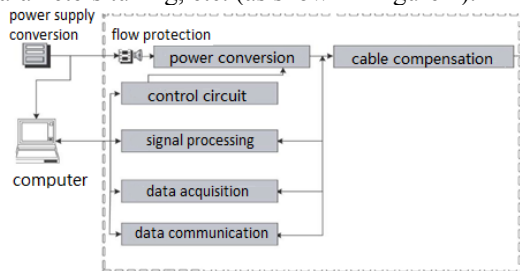


Figure 2: Structure diagram of ground control system.

### 3.3 Straight-Reading Electric Measuring Instrument

Straight-reading electric measuring instrument mainly by mechanical arm, the control part, measuring parts, steering mechanism and so on, by receiving the ground sends commands, adjusting arm, release and adjustable plug docking, flow testing adjustment, temperature, the stress state of measurement and testing is done at the same. And has the data signal modulation and demodulation and transmission function (as shown in figure 3).

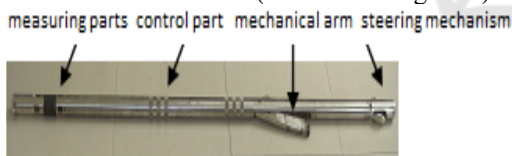


Figure 3: Physical drawing of the instrument.

### 3.4 Adjustable Plugging Device

The adjustable plug is the actuator of the straight-reading electric measurement system, which is the core part of the whole system. It is divided into two types: adjustable partial pressure plug and adjustable molecular plug.

#### 3.4.1 Adjustable Partial Pressure Plug

From the design points of polymer flooding process integration injection process pressure regulating elements, use of non-newtonian fluid mechanics

theory and the flow field simulation software, optimize the pressure regulating element structure parameters, by adjusting the throttle element of effective length, control single injection pressure, achieves stepless adjustment of the first-level dispensing tool from low pressure loss to high pressure loss, to meet the needs of different injection.

#### 3.4.2 Adjustable Molecular Plug

The existing separation technology adopts single water nozzle to adjust the molecular, and the adjustment range is less than 30% when the flow injection quantity (20-50m<sup>3</sup>/d) is lower, and when the injection scheme is changed, it needs to be put out the water mouth, which is cumbersome and inefficient. New type adjustable molecular plug by adjusting the number of nozzle to control the polymer solution degree of shear, to achieve high shear, low pressure loss, the continuous adjustable molecular weight, the injection of polymer molecular weight are best match of reservoir permeability, maximize the effective use of low permeable reservoirs.

### 3.5 Cable Winch System

To ensure the running of the measurement and control system, developed a special cable winch system, adopts the cylinder and the steel cable wire roller double drum structure, steel wire used for plug fishing, steel cable for test, two drum independent operation, common hydraulic drive system, operation convenient, flexible. The tension system shows the cable tension in the process, which is beneficial to construction operation and improve cable life. Winch uses two kinds of mechanical and electronic counting methods to realize complementary advantages and ensure the accuracy of depth.

## 4 FIELD APPLICATION

By the end of 2017, straight-reading electric measurement technology in the application of more than 300 Wells, 3-5 layer average single well test time reduced to 2.5 days from 5.2 days, measuring efficiency could be improved by more than 2 times. It can be seen from the comparison with conventional steel wire test, that the more the number of single Wells layer is divided, the more obvious the effect of electric measurement is, and

the efficiency of the well above 5 layers is nearly 3 times than normal test .

9. Li,H,C. 2012, Overview of Separate Injection Technique for Polymer Flooding in Daqing Oilfield, Oil & Gas Geology

## 5 CONCLUSIONS

4.1 the straight-reading electric measurement technology realizes the straight-reading test and the continuous adjustment of layered flow, and the measuring efficiency is more than twice than the conventional process.

4.2 the polymer flooding straight-reading electric measurement technology is compatible with the water, and remains unchanged in the management of the underground pipe column composition, technology and test data.

4.3 by contrast, uniform polymer flooding injection pipe column, expansion of polymer flooding injection well straight-reading electric measurement technology field application scale, and improve the measurement and adjustment process.

4.4 the next step is to carry out the new type of polymer flooding automatic measurement and adjustment technology, so that the polymer flooding can be developed intelligently and digitally.

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