

## New Test Method for HTHP Filtration of Drilling Fluid

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**Abstract.** This paper introduces the working principle, main technical parameters and main advantages of Fann Permeability Plugging Apparatus (PPA) and Automated Permeability Plugging Apparatus (APPA), a new type of high temperature and high pressure filtration plugging test instruments, which are popular at present. Some main problems encountered in the current HTHP mud filtration plugging test are analyzed and corresponding countermeasures are put forward.

### Introduction

The exploration and development of deep resources has become one of the important tasks. Drilling holes are getting deeper and deeper, safe and efficient drilling is facing the test of downhole high temperature and high pressure. How to evaluate the filtration and plugging performance of drilling fluid under HTHP conditions more accurately is particularly important. There are advanced testing instruments and evaluation methods.

This paper introduces in detail the working principle and main technical specifications of Fann PPA manual filter plugging tester and Fann APPA automatic filter plugging tester, which are widely used by drilling contractors at present, and makes a comparison between their advantages and the conventional filter plugging test methods.

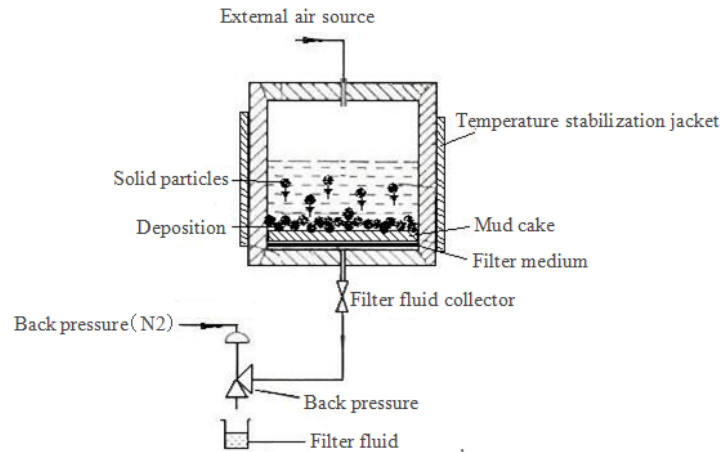
### The Operation Principle of the Permeability Plugging Apparatus (Fann PPA)

As shown in Figure 1, the manual filter plugging tester PPA (Permeability Plugging Apparatus) developed by Fann Instrument Company is similar in shape to the conventional high temperature and high pressure filtration, but the working mode and technical parameters of the two are quite different.



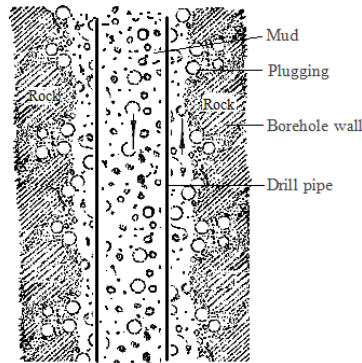
**Fig. 1** PPA designed by Fann® Instrument Company

Fann PPA manual filter plugging tester is designed and improved by borrowing some design principles of conventional 500 mL HTHP filtration. The fundamental difference between the two is that the conventional HTHP filtrations place the filter media (such as filter paper) at the bottom of the mud cartridge, and the drilling mud is composed of many different additives, such as barite with solid particles used to aggravate the mud, and bridge-type materials such as walnut shell powder is added to enhance the plugging effect. These solid particles under the action of gravity will be deposited on the filter media, forming a thick and loose layer of isolation between the drilling fluid and filter media. It is not conducive to the formation of thin and dense filter media cake; this situation will lead to the loss of water on the high side of the test. Shown as Figure 2.



**Fig. 2** Solid particles depositing in the mud cup

In the drilling process, the mud skin formed by the drilling fluid column in the wellbore is used to plug the fractures, pores and permeable formations on the vertical wellbore. The solid particles deposited at the bottom of the wellbore have no effect on sealing the wellbore leakage. Shown as Figure 3. Therefore, there is a big difference between the conventional HTHP filtration test method and the actual situation of drilling process. The test results of water loss can not completely reflect the actual situation of drilling fluid.



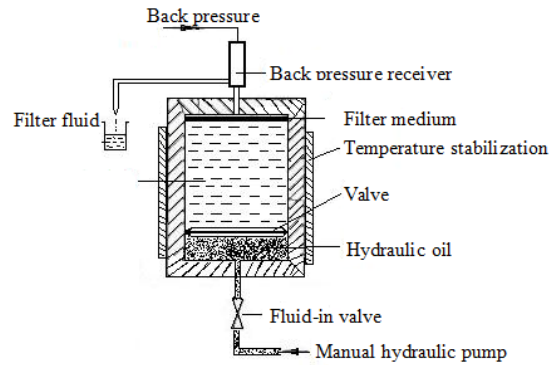
**Fig. 3** Mud plugging in well drilling

The test with PPA can effectively avoid the influence of solid particle sediment on the loss of water and the state of mud cake, and the measured results are more in line with the actual situation of drilling. The mud cartridge, piston and matching T shaped tools of Fann PPA are shown in Figure 4.



**Fig. 4** Valve and T pump of the mud cup

Compared with conventional HTHP filtrations, the Fann manual filter plugging tester PPA places the filter media (such as filter paper or core disc) and the back pressure receiver at the top of the mud drum. The external manual hydraulic pump drives the piston in the mud drum upward with the hydraulic oil at the bottom of the mud drum. The filtrate filters out from the filter medium and forms a blocking mud cake on the filter medium, as shown as Figure 5.



**Fig. 5** Fann PPA working principle

A number of experimental results show that the increase of mud density will lead to an upward trend of filtration. The loss of water measured by PPA is smaller than that measured by conventional test methods, and the former can reflect the real filtration plugging characteristics of drilling fluid in the actual situation.

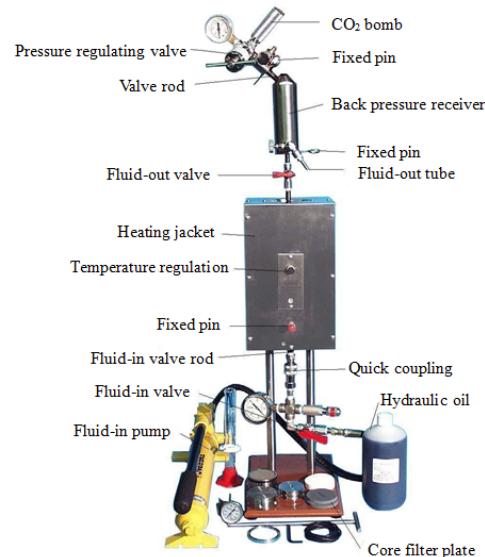
For example, a kind of 2.0g/cm<sup>3</sup> water-based weighted mud was tested with a conventional Fann 71 HTHP filter press and Fann PPA at the same experimental conditions (temperature 150 C, positive pressure 500 psi, backpressure 100 psi), and the filter loss result provided by the former is 14ml while PPA provides the results as 9ml. When the density was further increased to 2.2g/cm<sup>3</sup>, the filter loss provided by conventional test method was 16 ml while PPA provides the results as 10ml.

The maximum test temperature and pressure of PPA can reach 260°C and 35MPa, which can better simulate the real environment conditions of high temperature and high pressure in deep wells and test the filtration plugging characteristics of drilling fluid under HTHP. PPA uses a mud cartridge with two open ends, thus ensuring compatibility with conventional HTHP filter media (such as filter paper, artificial core filter disc, high temperature medium disc, high temperature glass fiber filter screen, etc.). Two different screen end caps are shown in Figure 6.



**Fig. 6** Two type mud cup end

Figure 7 shows the structure of Fann PPA. The CO<sub>2</sub> gas bomb shown in the figure is used to provide backpressure, or it can be supplied by a nitrogen cylinder by using a switch connector.



**Fig. 7** Fann PPA structure

### The operation principle of the Automated Permeability Plugging Apparatus ( Fann APPA)

The Fann Automated Permeability Plugging Apparatus (APPA) shown as Figure 8 provide an exceptional reproducible environment for testing a drilling fluid's ability to minimize fluid loss and achieve an optimal filter cake on the well bore.



**Fig. 8** Fann Automated Permeability Plugging Apparatus

Traditional permeability plugging tests require the operator to manually manage the timing, pressure control, and filtrate collection during the test. The Model 389 AP and MC combination eliminates the need for continuous operator intervention and promotes testing automation and repeatability.

Advantages:

- Automatic pressure control, bottom side pressurization prevents settling of solids
- Filtering media comes in various pore sizes, compatible with all current APPA cells
- Fully automated for continuous collection of filtrate
- Graph illustrating real time data, on-board test data storage
- Fluid loss data logged/plotted, view/compare multiple test results simultaneously
- Run extended 16+ hr tests without an operator present
- Fluid loss measurement repeatability of 0.1 mL
- 40mL receiver 'flush' feature – eliminates need for removal/cleaning after every test

## Solutions about HTHP Mud filter Loss Test on Properties of Materials

The drilling fluid testing technology and instrument are improving with the drilling engineering technology. Because of the complicated conditions and various instruments and test methods, the test results are usually different. That results in disagreement among the producer and testing organization or different testing organizations. Main questions are listed following:

1. The material of filter medium can make evident influence on filter loss test results. Taking filter paper as an example, the properties of materials specifications such as thickness, density, homogeneity, tensile strength, thermal endurance, uniformity can make evident influence on filter loss test results. The Fann filter paper is tough and uniform, not easy to be destroyed. Some China-made filter paper is thin, no uniform and can't withstand high temperature, so it is easy to be destroyed during test, resulting test failure.

2. Specific filter medium must be used in high temperature test. Filter paper may carbonize above 160°C and is easy to be destroyed under high pressure. Some operators use double filter paper to avoiding destruction, leading to fake test results. Using high temperature resistant glass fiber net or high temperature stainless steel medium plate (300°C) solves this problem. Choosing high temperature resistant artificial core according to filter formation permeability is also available.

3. The temperature and pressure are usually not completely the same; it will reduce the test results consistency of HTHP mud or fracturing fluid. Quadruple HTHP filter press can solve the problem. The positive pressure and back pressure are controlled by one pressure manifold, so the pressure on 4 samples is completely the same. It improves the test consistency of parallel samples.

4. There are many other factors influencing the test results. Using an average of several testing results can improve the accuracy.

## Conclusion

The filter loss of drilling fluid under dynamic HTHP condition is more and more important to the safety, quality and speed of drilling extra-deep well. Different filtration may provide different test results. Generally, choosing the same instrument type to stakeholders' can get a better test results, avoiding disagreement on quality conformance.

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