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Research on Safety Monitoring System of Bottom Hole Pressure in Coalbed Methane Underbalanced Drilling Process

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Abstract: During coalbed methane underbalanced drilling process, because of coal's low mechanical strength, the coal seam can not support overburden pressure, which is likely to lead to sloughing and collapsing in coal seams; besides, as coal seams in China have low pressure and low permeability, they are prone to be contaminated. as a result, it is easy to occur various complicate situations in downhole if the bottom hole pressure exceeds the designed safety range, which threatens life and property. In the light of the coalbed methane cavity aerated underbalanced drilling, this paper puts forward a bottom hole pressure safety monitoring technology for monitoring in the coalbed methane cavity aerated underbalanced drilling, designs and develops assorted bottom hole pressure safety monitoring system that can monitor and analyze bottom hole pressure during the drilling process timely, ensures safe construction of coalbed methane underbalanced drilling, and keeps bottom hole pressure steady in real time during the coalbed methane underbalanced drilling. This template explains and demonstrates how to prepare your camera-ready paper for Trans Tech Publications. The best is to read these instructions and follow the outline of this text.

Keywords: Bottom hole pressure, coalbed methane, monitoring system, underbalanced.

1. INTRODUCTION

During coalbed methane underbalanced drilling process, because of coal's low mechanical strength, the coal seam can not support overburden pressure, which is likely to lead to sloughing and collapsing in coal seams; Besides, as coal seams in China have low pressure and low permeability, they are prone to be contaminated, causing yields. Therefore, most of China's coalbed methane development is use to underbalanced drilling technology. To ensure the safety of coalbed methane underbalanced drilling process and the stability of the final production, it is necessary to monitor bottom hole pressure during the drilling process timely.

At present, there is complete control pressure drilling technolog abroad, major companies have developed corresponding supporting software and hardware systems, which has made a well application effect in the field [1-4]. The research in control pressure drilling technolog start late in china, for recent years, a number of scientific research have got a little pressure control technology with independent property rights, but the research and development about corresponding supporting software and hardware systems is still lagging behind, while the cost of direct introduction of foreign technology is too high. In the light of the coalbed methane cavity aerated underbalanced drilling, combined with rational analysis of field equipment this paper puts forward a bottom hole pressure safety monitoring technology for monitoring in the coalbed methane cavity aerated underbalanced drilling, designs and develops assorted bottom hole pressure safety monitoring system, and enter the field test.

2. THE COALBED METHANE CAVITY AERATED UNDERBALANCED DRILLING

Since the 19th century, United States have aimed to explore and develop coalbed methane, and now a corresponding series of coalbed methane development technology has been set [5]. The research and evaluation of coalbed methane resources start late in China, the corresponding development of coalbed methane drilling technology gradually form through the introduction, testing, absorption, and Redevelopment [2]. Since the 1990s, in the light of a variety of process technologies china have conducted a large number of pilot tests, including that vertical wells gas production is low, but problems of production dips exist in multi-branch horizontal wells [6]. In order to solve and prevent the occurrence of such cases, China adopted The coalbed methane cavity aerated underbalanced drilling. The structure of this technology is shown in Fig. (**1**).

It is known from the construction process after the cave straight and horizontal wells connected, it will use the coalbed methane cavity aerated underbalanced drilling. In this case, there is gas liquid solid three phase flow in the

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section vertical well after gas injection annulus in the horizontal well (cuttings are carried in the drilling fluid), which lead to use of multiphase flow model analysis. It remains liquid-solid two-phase in the section vertical well before gas injection. Visible to directly let gas injection wells as a dividing line, there is dual gradient pressure in the wellbore.

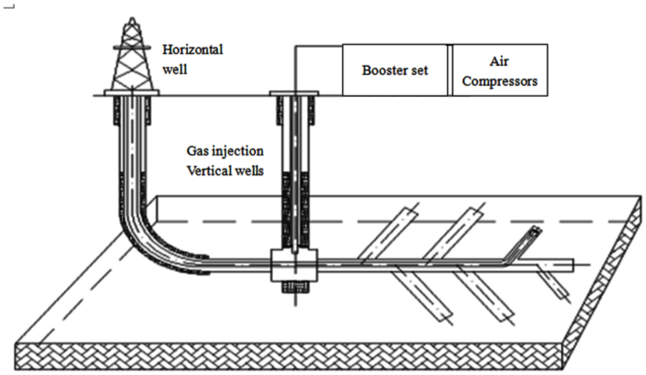

Fig. (1). The structure of the coalbed methane cavity aerated underbalanced drilling.

3. THE STUDY OF WELLBORE FLUID FLOW IN THE COALBED METHANE CAVITY AERATED UNDERBALANCED DRILLING

Based on the analysis of drilling technology above, In the light of the requirement of low-cost development on coal methane drilling, It have to put aside the expensive downhole measurement tools and use ground-based measurements to achieve real-time monitoring on safe of bottomhole pressure during drilling process. The wellbore fluid flow analysis model supporting auxiliary must be systematic and thorough studied.

Physical Model. Combined with the coalbed methane cavity aerated underbalanced drilling and its well structure, the establishment of the physical model shown in Fig. (**2**).

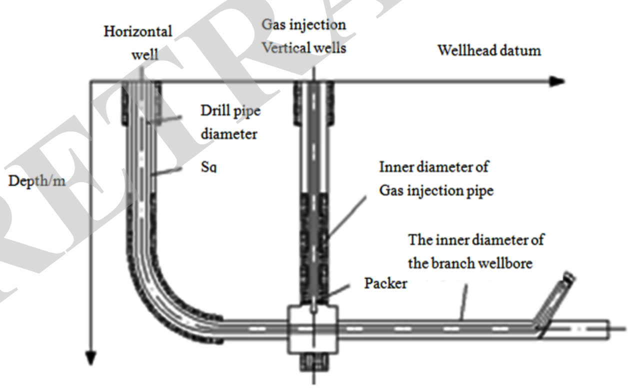

Fig. (2). Physical model.

3.1. The Optimal Choice of Flow Analysis Model

3.1.1. The Optimal Choice of Single-Phase Flow Model

As coal seams are prone to be contaminated, Drilling fluid chooses water during coal seam drilling process. And the last, through analysing the Newton model, power-law model, Carson model, He - Pakistani model and fluid model API2003, choosing the Newton model as the single-phase calculation model of water drilling fluid and the API2003 as mud single-phase computational model of drilling fluids to ensure its accuracy.

3.1.2. The Optimal Choice of Multiphase Flow Model

As can be seen from the physical model of coalbed methane wellbore, there is gas - liquid - solid three-phase flow in the annulus from Wellhead to the point of gas injection wells. Coalbed Methane is mainly adsorbed in the formation and a small amount of it dissolved in formation water, free is negligible, so gas flow mainly based on injecting gas flow. As solving the three-phase flow field is very difficult, Liquid-solid two-phase is considered as miscible in order to facilitately research and calculations [7] and make followed assumptions of the model:

A Do not consider the compressibility of the mixed phase, the cycle of gas mixed two-phase flow mode is positive cycle;

B Gas mixed phase flow in the wellbore makes one-dimensional flow along the wellbore axis;

C In anywhere of inside section, pressure and temperature are equal and in thermodynamic equilibrium;

D when consider of mass transfer between gas mixed phase flow, the thermodynamic equilibrium is reached in an instant.

E Each of the single-phase velocity are equal in inside section.

Currently, the multiphase flow model abroad adopted roughly divided into three categories: □ flow pattern model (empirical formula model, mechanical model) □uniform flow model ⊛ drift flow model.

As coal seams in China have low pressure, low permeability, ainly buried shallow, low temperature and the changes in flow regime fails to comply with the Flow map above, compare with the three types of model above, it is preferable of homogeneous flow model, and use Guo Boyun model as computing model of real-time dynamic monitoring and underbalanced drilling control analysis [8].

Establishing and solving wellbore flow analysis model. Establishmenting coal methane drilling wellbore flow analysis model through established Physical models and preferred flow model, This model divide the wellbore into many small disjoint pieces, the pressure drop calculation carried out in accordance with subparagraph location of each section. Using multiphase flow analysis model to calculate due to there is multiphase flow in the wellbore from Wellhead to the point of gas injection wells; because there is fluid - solid two-phase in the wellbore from the depths of the well to the point of gas injection wells, it uses single-phase flow analysis model to calculate. Single-phase flow model uses the method of direct calculation. And for multiphase flow model, this paper apply Newton's iterative method to solve, the specific model Solve Loop followed:

(1) The well bore is cut into multiple segments which do not intersect, and the structure parameters are

calculated for each segment when Starting point is for the calculation of the current depth and the depth of the gas injection point is for split point, at the same time according to the well construction and drilling assembly parameters.

(2) Import known parameters: mud displacement, gas injection, gas, liquid density and viscosity, wellhead back pressure, wellhead temperature, geothermal gradient, gas injection point location and so on;

(3) Inclination data Based on collection, formation pressure coefficient data, time-based data and so on, each segment`s gas-liquid physical parameters start calculating from the wellhead. gas critical temperature, pressure, viscosity, density, conversion rate, volume factor, density, mixed speed and so on;

(4) The iterative computation for gas-liquid two-phase pressure drop of each segment from the wellhead to the point of gas injection applies multiphase flow model (Guo model), which`s Accuracy is 10-3, and it adds cave segment pressure drop correction value;

(5) The direct calculation for the physical property data and pressure drop of each segment from the point of gas injection to the current well applies single phase flow model,

(6) Integrate and storage the results of The multiphase flow model and single-phase flow model

Dynamic analysis of the flow chart shown in Fig. (**3**).

4. FIELD APPLICATION EXAMPLES

According to the research about process and wellbore flow analysis above, this paper puts forward a bottom hole pressure safety monitoring technology for monitoring in the coalbed methane cavity aerated underbalanced drilling: the hardware systems design and the underbalanced bottomhole pressure monitoring software security system are used of supporting wellbore flow analysis model based on ground measurements, coalbed methane gas injection cave underbalanced drilling bottomhole pressure real-time monitoring Applies back pressure Control Act and injected flow control method, and this technology is used in the well block site testing system in Well Xx of Block YY.

Block XX YY well is a test wells, The well is three Φ152.4mm borehole and the gas injection point is wellbore 978m. Applications for system tests in 1020 ~ 1082m hole section, the relevant input parameters are as follows:

Drilling parameters: water; Density: 1.09g/cm3; Viscosity: 43s; sandy 0.2%; PH value 8; rheological models: Newtonian fluid; operating parameters: the annulus gas injection -22m3/min; pump displacement -18L/s, ground throttle pressure - 0.5MPa; other parameters: cuttings diameter -8mm, cuttings density -1.4g/cm3; geothermal gradient -1 °C/100m, formation water density -1.07g/cm3.

The interface of Real-time monitoring shown in Fig. (**4**), the results of dynamic analysis are shown in Table **1**.

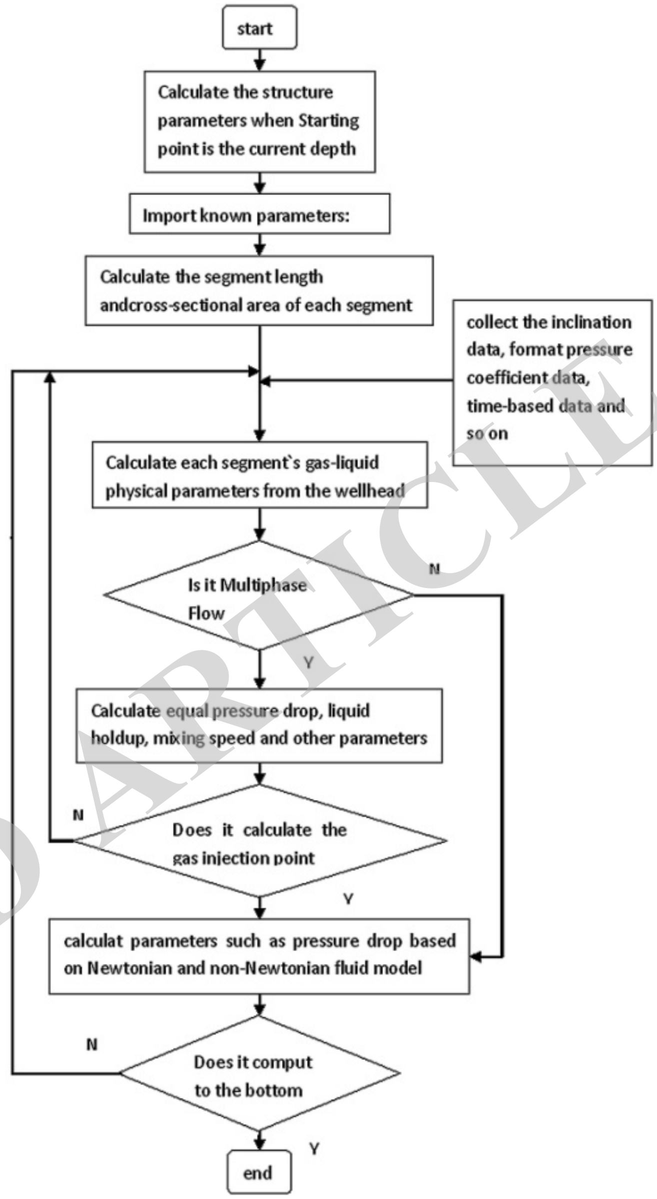

Fig. (3). Flowchart of model dynamic analysis.

It spends 2 hours to real-time monitor and real-time control the bottom hole pressure to ensure that the bottom hole pressure is always within a reasonable and controllable range. The Monitoringaccuracy meet on-site construction requirements and control precision is up to 0.2Mpa.

CONCLUSION

This chapter studied coalbed methane cavity aerat underbalanced drilling technology and assort bottom hole pressure safety monitoring system, and draw the following conclusions:

(1) The paper establish the wellbore flow analysis model base on multiphase flow, single phase flow theory model and coalbed methane cavity aerat underbalanced drilling construction technology,

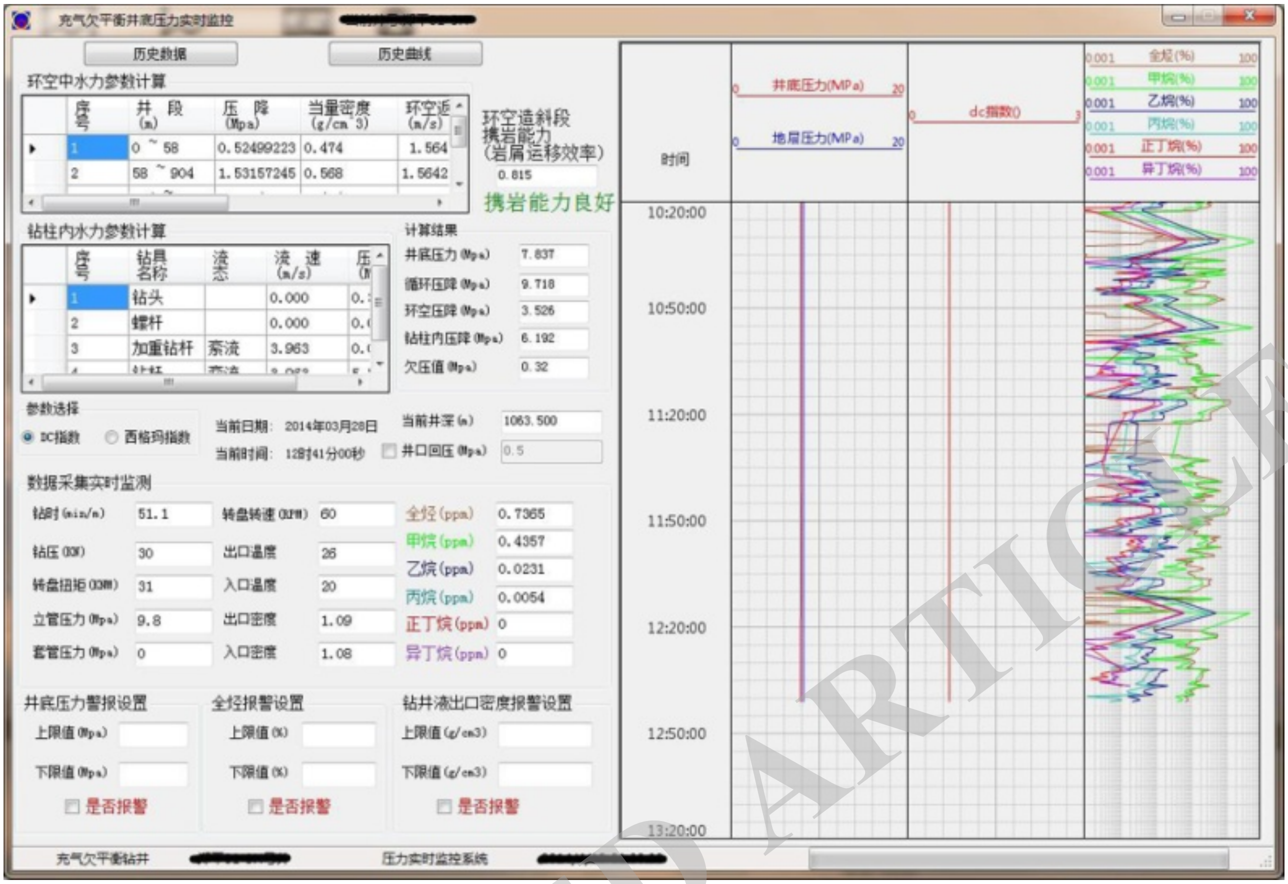

Fig. (4). Site implementation monitoring interface figure.

Table 1. Dynamic analysis results.

Dynamic Analysis Parameters	Dynamic Analysis Results [Mpa]
Bottomhole pressure	7.844~7.865
Circulation pressure drop	9.687~9.718
Annulus pressure drop	3.512~3.526
Pressure drop in the drill string	6.175~6.192
Undervoltage value	0.293~0.32

which provides theoretical basis for the design and development of coalbed methane cavity aerat underbalanced drilling bottom hole pressure safety monitoring system. Moreover, through application practice, its model precision and adaptability is verified. The final result shows that it meets the requirements of construction site.

(2) The coalbed methane cavity aerat underbalanced drilling bottom hole pressure safety monitoring method, which depends on engineering parameters collected from ground measurements, works well in the exploitation of coalbed methane. In addition, it satisfies the present coalbed methane requirement of low cost in China.

(3) The field test proves the accuracy of the wellbore fluid flow analysis model as well as the adaptability and feasibility of safety monitoring method. Furthermore, it can reduce or avoid the occurrence of down hole accidents timely and effectively, which improves the safety of the coalbed methane cavity aerated underbalanced drilling construction process.

(4) The coalbed methane cavity aerat underbalanced drilling bottom hole pressure safety monitoring system proposed in this paper, It can carry out real-time accurate monitoring of bottom hole pressure in the coalbed methane cavity aerat underbalanced drilling. In view of the complicated down hole conditions, It can make real time control and analysis timely and reliably. By this means, it provides reliable data support and decision-making basis for technicians.

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