Research on the vibration test of drill string

Fengjie Xu [a]

School of Southwest Petroleum University, Chengdu 610000, China

[a]15828636525@163.com

Abstract

This paper summarizes the research progress of drill string vibration and its theoretical research, Points out the drill string vibration on drilling process brings serious harm and the main root cause, exposed the history and present state of the study of the diamond column vibration measurement technology at home and abroad. This paper Studied the drill string longitudinal vibration, lateral vibration and torsional vibration based on the pattern and pressure of the drill column and introduced the several key factors influencing the drill string vibration. Finally, the accelerometer is used to measure the vibration signal of drill string.

Keywords

Drill string vibration, bit pressure, Drill string vibration test system.

1. Introduction

The serious harm of drill string working under resonance is well known, and there is no functional module that can directly measure vibration in the previous drilling-down measurement instrument, it can only through torque, pressure and other underground mechanical parameters indirectly reflect the vibration of drill string. In recent years, with the development of drilling logging and drilling logging technology, the new type of vibration sensor has been constantly emerging and the underground measurement technology has been continuously updated. Based on the background of drilling and drilling, this paper makes an analysis and comparison on the vibration test technology of the drill, the main contents of this paper are as follows: (1) Studied the theory of drill string vibration which includes vibration testing technology, the reason of the vibration of drill string and the vibration rules. (2) Studied the most advanced vibration test technology and its important cases. (3) Studied the method of longitudinal vibration of the ground in China is studied and the inversion calculation of six strain films.

2. Drill string vibration test system

2.1 System composition

The drill string vibration test system consists of two parts: hardware system and software system. The overall design block diagram of drill string vibration test system is shown in Fig .1.

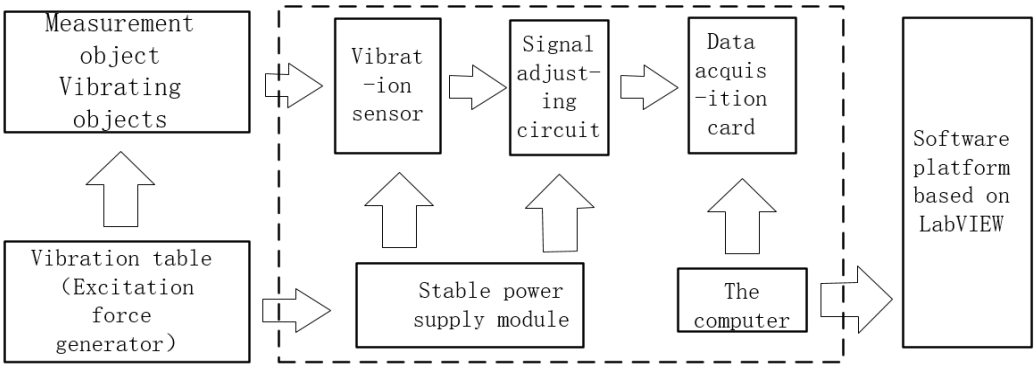

Fig. 1 drill string vibration test system

2.2 Drill string vibration test system hardware system

The overall structure of the drill string vibration test hardware system consists of a piezoelectric acceleration sensor, a charge amplifier, a data acquisition module, and a computer, as shown in figure 4. The sensor converts the vibration signals of the pickup to analog signals (electrical signals), then a charge amplifier converts a weak charge signal into a voltage signal, and the A/D conversion and sampling quantization are performed through the data acquisition card, so the analog signals become digital signals. In the end, the sampling signal is sent to the computer for the vibration test analysis software to analyze the signal. The overall framework of the hardware system is shown in Fig. 2.

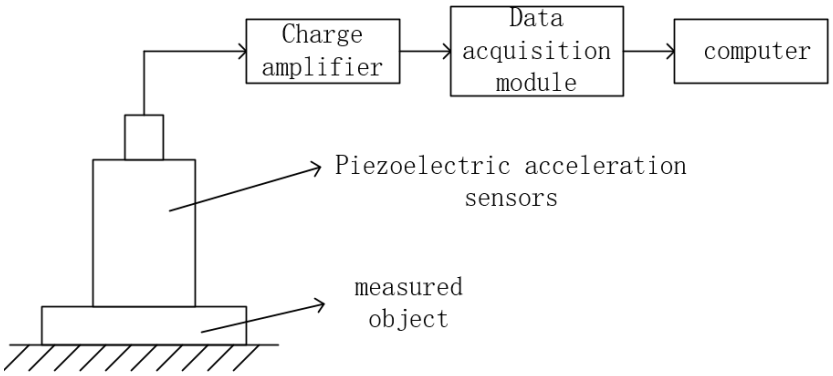

Fig. 2 Hardware system framework

2.3 Drill string vibration test system software system

The software system used the Labview graphical programming language and has two basic Windows for the front panel and the program block diagram. The main function of front panel is to place the basic display control and waveform display diagram, which can be used to identify and judge the results of data processing. The program block diagram is mainly to write the relevant program source code, complete the signal data collection, analysis and processing tasks. Program flow chart is shown in Fig. 3.

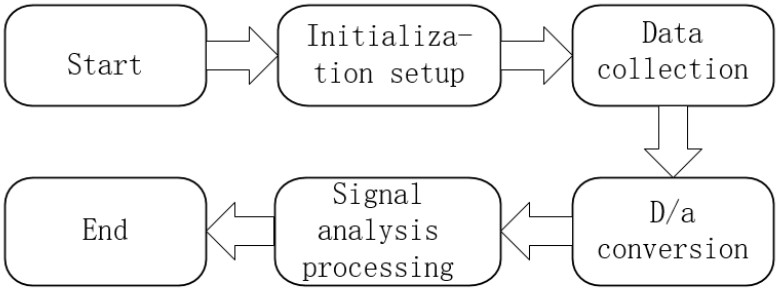

Fig. 3 Program flow chart

3. Vibration test

3.1 bit pressure

In the big displacement well, slimhole Wells and horizontal Wells on drill's weight to the bit exerting wob is very difficult, to solve this problem, people developed a way to use high pressure drilling fluid to provide drilling pressure of hydraulic pressure. Hydraulic pressure actuator is a more practical drilling technique which can convert the hydraulic fluid of the pump to the drilling fluid into the mechanical energy, which is mainly used in drilling and repairing. The high-pressure drilling fluid has a downward thrust against the piston in the cylinder, according to the principle of fluid mechanics, the force F generated at the upper end of the piston is:

$$F = PA \tag{1}$$

Where:

F represents the drilling fluid acting on the piston thrust, KN

P represents the internal and external pressure difference of hydraulic pressor, MPa

A represents the cross-sectional area of the force, CM^2

If the pressure principle of hydraulic pressor is analyzed from the Angle of energy conversion, The hydraulic pressure device is actually like an energy conversion device, The mud pressure can be converted into the drill pressure applied to the drill bit to enable the drill to rock drilling, The flowchart in Fig. 4 can be used to describe the principle:

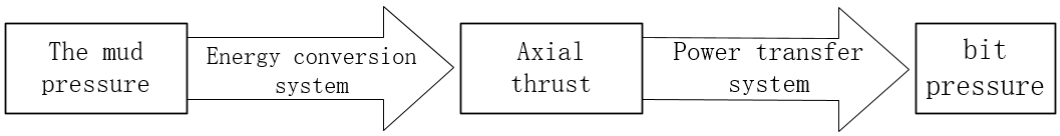

Fig. 4 Energy conversion flow chart

3.2 Drilling pressure fluctuation

For more specific analysis of how the hydraulic presser reduces the fluctuation of the drilling pressure, we build a stress model as shown in Fig. 5:

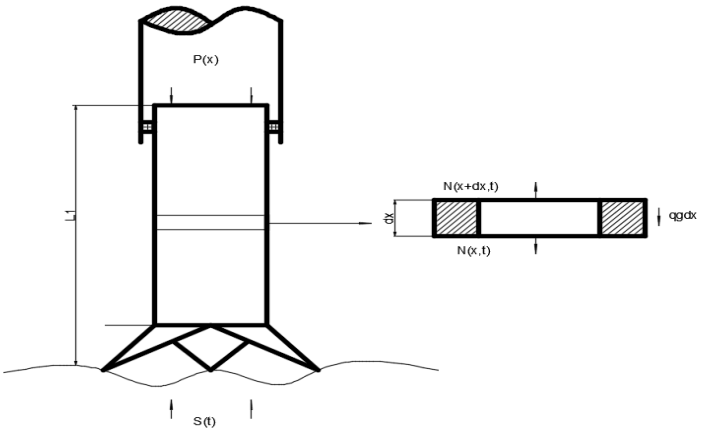

Fig. 5 Hydraulic pressor model

In order to better represent the damping characteristics of the hydraulic presser and the damping characteristics of the other part of the lower part of the drilling tool, We introduce a comprehensive damping coefficient C_i, The relationship between the damping force F_d and the damping coefficient C_i is as follows:

$$F_d = -C_i v \tag{2}$$

Where:

v represents the instantaneous velocity of the bit longitudinal vibration, $\mathrm{m/s}$

Then the following equation can be obtained by applying Newton's law of motion to the lower drilling tool:

$$m_{bha} a = F(t) - WOB_O - C_i v \tag{3}$$

Where

m_{bha} represents the quality of the bottom assembly, kg

$F(t)$ represents the reaction of the formation to the drill bit, N

WOB_O represents the Static drilling pressure added to the drill bit, N

a represents the acceleration at the bit, $\mathrm{m/s^2}$

According to the relationship between the force and the reaction, The inverse force $F(t)$ of the formation is opposite to the instantaneous drilling pressure WOB_O of the drill, The derivative relationship between displacement and acceleration and velocity is introduced:

$$\mathrm{v} = \frac{\partial u(x,t)}{\partial t} \tag{4}$$

$$WOB(t) = F(t) \tag{5}$$

$$WOB(t) = m_{bha}\ddot{u} + C_i\dot{u} + WOB_O \tag{6}$$

$$\mathrm{a} = \frac{\partial^2 u(x,t)}{\partial t^2} \tag{7}$$

This formula gives a very clear formula for the change of instantaneous drilling pressure over time, and it is very clear to know the actual situation of bottom hole drilling pressure.

4. Conclusion

This paper briefly studies the theory of drill string vibration, analyzed the causes of vibration and the law, built the drill column vibration test system. However, in the process of drilling, because the underground conditions are complicated and changeable, the data information is difficult to measure and collect, so the theoretical research on the vibration of drill string is still not comprehensive, it is necessary to develop deep, comprehensive and detailed theoretical analysis in future learning.

References

[1] Zhan Qu, Dezhu Liu, “The vibration of drill string and its theoretical research progress,” China Petroleum Machinery, Vol. 02(1996), 54-57.
[2] Chunjie Han, “Analysis and application of vibration rule of drill string in deep well,” Natural Gas Industry, Vol. 09(2005), 76-79.
[3] Qinfeng Di, “Research progress of drilling column vibration information measurement technology,” Mechanics In Engineering, Vol. 05(2015), 565-567.
[4] Ruiwen Liu, Zhichuan Gan, “On-line monitoring and application of drill string vibration signal,” Journal of Vibration and Shock, Vol. 01(2013), 60-64.
[5] Qingyou Liu, Guorong Wang, “Structure design and drilling pressure calculation of small hole hydraulic pressure device,” Acta Petrolei Sinica, Vol. 02(2009), 304-307.