World Scientific Research Journal Volume 8 Issue 5, 2022
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

Interference Analysis of LWD Transmission Signal in Bohai X Oilfield

Le Peng[1], Guoqiang Zhang[2], Ruming Liu[1], Linpeng Yang[1]
[1]CNOOC EnerTech-Drilling & Production Co. , Tianjin, 300452, China
[2]Tianjin Branch of CNOOC Ltd. , Tianjin, 300459, China

Abstract

Logging while drilling instrument can measure various parameters of formation in real time during drilling. The measured parameters are closer to the characteristics of undisturbed formation, which is particularly key to drilling safety and enhanced oil recovery. At present, the signal transmission mode of LWD tool is mainly drilling fluid pressure pulse transmission. During drilling, the signal of LWD tool is easy to be disturbed by a variety of downhole chaotic signals, resulting in failure to decode and effectively transmit real-time data, which brings interference to real-time drilling and geological decision-making. Through the analysis and Research on the effective signal and noise in the process of MWD measurement in multiple wells of Bohai x oilfield, a method to effectively avoid the interference of real-time signal of LWD is obtained, and a good application effect is obtained in multiple wells of Bohai x oilfield.

Keywords

MWD; Signal transmission; Pressure wave; Noise; Acquisition; Classification; Frequency modulation.

1. INTRODUCTION

Logging while drilling refers to measuring the petrophysical characteristics (lithology, physical properties, etc.) of the formation around the wellbore during drilling. The results measured by LWD tool measuring instrument can be used to evaluate the reservoir during drilling or after well completion. In order to transmit data, LWD tool sends its measurement results to MWD tool; MWD tool sends the pressure wave through the mud in the drill string as the information transmission carrier to the ground. After downhole coding and ground decoding, it is processed into real-time logging data on the ground computer [1].

LWD real-time data can not only provide engineering parameters such as well deviation, azimuth and ECD, but also provide formation parameters such as lithology, electrical property and porosity. Whether in the drilling of vertical wells, directional inclined wells, ultra deep wells and large displacement horizontal wells, mastering the downhole engineering parameters and geological parameters in real time can ensure the normal progress of drilling work, which is very important for drilling safety, reducing drilling cost and improving oil recovery [2].

At present, the mainstream transmission type of MWD instrument is drilling fluid pulse wave transmission, and the transmission medium is mud; However, in the process of drilling, the pulse wave of drilling fluid will be disturbed by a variety of noises in the propagation process, resulting in low signal-to-noise ratio of real-time transmission signal, unable to decode in real time, unable to obtain effective, accurate and high signal-to-noise ratio real-time data, which has a significant impact on drilling operations.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

2. STUDY ON TRANSMISSION MODE OF LWD

MWD data transmission technology is mainly divided into wired transmission and wireless transmission. Wired transmission mode has fast transmission speed, but it needs to stop drilling for measurement, which has a great impact on drilling effectiveness; Wireless transmission of drilling fluid includes acoustic wave transmission and electromagnetic wave transmission. Electromagnetic wave transmission mode is easily affected by borehole geological factors and well depth, which is greatly limited; The acoustic transmission mode has fast propagation speed, but it is greatly affected by the borehole environment. At present, it is still under development and does not meet the commercial conditions; Drilling fluid pulse transmission is the most widely used transmission mode at present.

ARPS JJ first invented the drilling fluid pressure pulse transmission technology in 1950. Later, beckhughes and Mobil successively studied the LWD signal transmission system. In the mid-1980s, teleco, Schlumberger and beckhughes [4-5].

The commercial logging while drilling (LWD) system has been launched successively. The drilling fluid pressure pulse transmission mode has developed rapidly because of its economic and reliable advantages, and is widely used in logging while drilling system.

The drilling fluid pressure pulse transmission mode adopts the pulse position combination coding mode to convert the downhole information into electrical signal, which is converted into pressure pulse signal through the mud pump. In order to meet the requirements of error control in the transmission process, the pressure pulse signal needs to be coded to improve the effectiveness of data information transmission, and then the drilling fluid is used as the transmission medium to complete the information transmission [3]. Mud pulse signal is vulnerable to external interference in the transmission process, and as a mechanical signal, there must be a certain delay and attenuation in the transmission process as energy transmission. Because the collected pulse signal contains noise signal and has delay and attenuation, in order to accurately and effectively identify the effective signal, it is necessary to select appropriate signal filtering method and data information decoding method to extract and analyze the pulse signal.

3. ANALYSIS ON INTERFERENCE SOURCE OF DRILLING FLUID PRESSURE PULSE SIGNAL TRANSMISSION OF LWD IN BOHAI X OILFIELD

Schlumberger LWD tool is used to measure while drilling in Bohai x oilfield, which adopts drilling fluid pulse wave signal transmission. Its basic working principle is that after the downhole measurement signal is encoded by the machine, the pressure pulse is generated by the pulser and transmitted to the ground sensor through the drilling fluid. The ground sensor then collects the pulse signal and obtains the measurement information through filtering and decoding. However, as a mechanical signal, the pulse signal needs to select appropriate signal filtering method and data information decoding method to extract and analyze the pulse signal in order to obtain accurate downhole measurement information. When the spectrum of mud pulse signal and noise signal is overlapped, the digital filter denoising method will blur the abrupt part of the waveform of the effective pulse signal while denoising the signal, A certain frequency band of noise signal can not be eliminated, which affects the signal decoding.

3.1. Analysis of Interference Source of Real-time Signal Transmission of LWD in well A

The Schlumberger tool neoscope + telescope was used to measure while drilling in the 8.5in hole of well a. the BHA is 8-1 / 2 "pdc-bit + 6-3 / 4" PDM + 6-1 / 2 "F / V + 6-3 / 4" neoscope + 6-3 / 4 "telescope + 6-3 / 4" NMDC + 6-1 / 2 "jar (hydraulic) + 5" hwdp × 14+5"DP × 9 + 6-3 / 4 "agitator + 5" DP + hydraulic oscillator (the hydraulic oscillator is 275m away from the bit), and the measurement tool while drilling is Schlumberger logging instrument neoscope. The

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

measurement items include natural gamma (12.00m away from the bit zero length), density (15.36m away from the bit zero length), neutron (15.30m away from the bit zero length), and resistivity (15.05m away from the bit zero length).

The instrument has no problem in the shallow test at the wellhead. The starting depth of 8.5in drilling is 2781.00m, and the signal transmission is normal, so the real-time data transmission can be seen. However, when the subsequent drilling reaches 3056.00m, the real-time signal transmission is faulty, as shown in Figure 1 below. At 3043-3053m, the formation resistivity curve measured by p16h / p40h shows an abnormally low value, the formation resistivity measured by p28h shows a straight line, and the formation density curve measured by Rhon shows a straight line, The neutron porosity curve of the formation measured by tnph is a straight line, which indicates that this section of data does not conform to the real characteristics of the formation and is a false value.

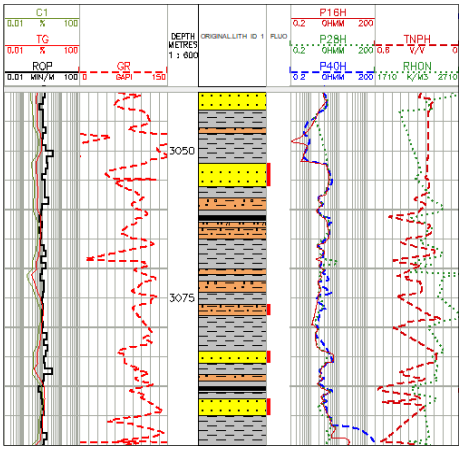

Figure 1. Chaotic real-time curve of real-time signal decoding while drilling

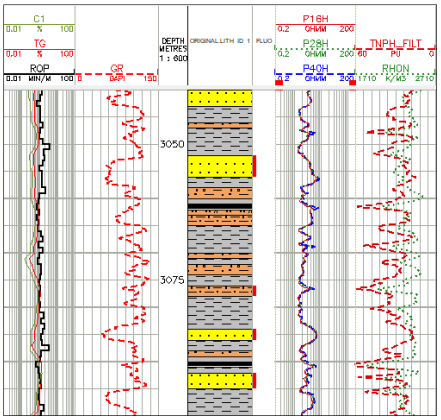

Figure 2. Schematic diagram of retest while drilling real-time curve

At this time, observe the decoding spectrum diagram of Schlumberger LWD tool (Figure 3). The main frequency of real-time signal decoding of LWD tool is set to 10.6HZ, and the signal band is (8.5-12.75HZ). There is an obvious periodic interference source (frequency is 10.8HZ) in the decoding frequency band of LWD tool. Analyze the engineering parameters such as BHA, drilling fluid displacement and rotary table speed. This periodic interference source is the axial vibration of hydraulic oscillator.

In order to ensure the real-time signal transmission of LWD and avoid the noise interference of hydraulic oscillator, resend the command, adjust the decoding main frequency of MWD

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

instrument to 4Hz (the signal band is 2.5-5.5HZ), and retest this section of curve. See Figure 2, the transmission signal of LWD real-time curve returns to normal.

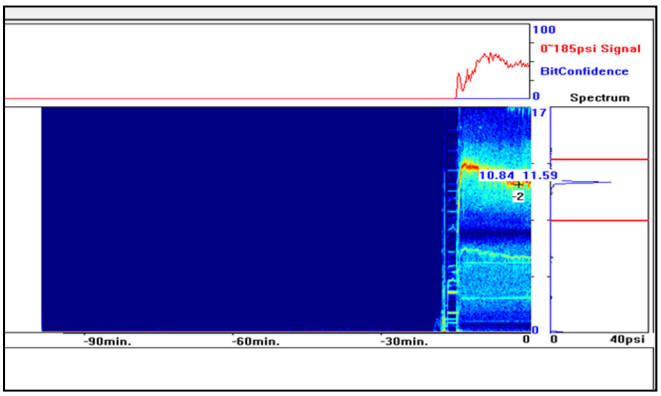

Figure 3. Noise interference spectrum of hydraulic oscillator

3.2. Analysis of Interference Source of Real-time Signal Transmission of LWD in Well B

The Schlumberger tool neoscope + telescope was used to measure while drilling in the 8.5in hole of well B. the BHA is 8-1 / 2 "pdc-bit + 6-3 / 4" PDM + 6-1 / 2 "F / V + 6-3 / 4" neoscope + 6-3 / 4 "telescope + 6-3 / 4" NMDC + 6-1 / 2 "jar (hydraulic) + 5" hwdp × 14+5"DP × 9 + 6-3 / 4 "agitator + 5" DP + hydraulic oscillator (the hydraulic oscillator is 275m away from the bit), and the measurement tool while drilling is Schlumberger logging tool neoscope. The measurement items include natural gamma (11.90m away from the bit zero length), density (15.26m away from the bit zero length), neutron (15.20m away from the bit zero length), and resistivity (14.95m away from the bit zero length).

When the 8.5in borehole was drilled to 3115m, it was found that the real-time signal decoding of LWD occurred, as shown in Figure 4 below. The resistivity (p40h), natural gamma (GR), neutron (tnph) and density (Rhon) curves were abnormal, which did not conform to the formation characteristics of this block. It was judged that there was a problem in the real-time signal transmission of LWD.

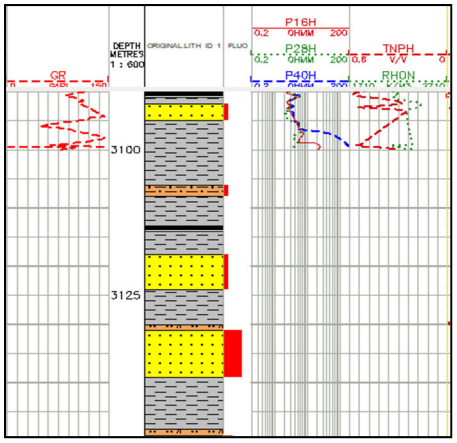

Figure 4. Chaotic real-time curve of real-time signal decoding while drilling

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

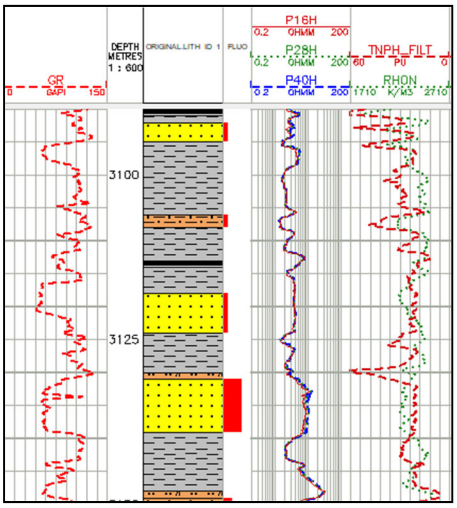

Figure 5. Schematic diagram of retest while drilling real-time curve

At this time, observe the decoding spectrum diagram of Schlumberger LWD (Figure 6). The main frequency of real-time signal decoding of LWD is set to 4Hz and the signal band is (2.5-5HZ). There is an obvious periodic interference source (frequency is 4.5HZ) in the decoding frequency band of LWD. Analyze the engineering parameters such as BHA, drilling fluid displacement and rotary table speed. The periodic interference source is the noise of rotary impulse motor.

In order to ensure the real-time signal transmission of LWD and avoid the noise interference of rotary impulse motor, resend the command, adjust the decoding dominant frequency of MWD instrument to 7Hz (the signal band is 5.5-8.5HZ), and retest this section of curve. See Figure 5. the transmission signal of LWD real-time curve returns to normal.

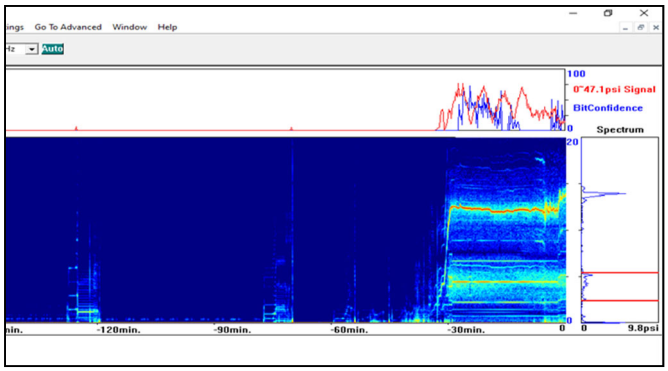

Figure 6. Spectrum diagram of noise interference of rotary impulse motor

3.3. Common noise analysis and Countermeasures of LWD

Through the analysis of the drilling operation of several wells in Bohai x oilfield, it is found that the common downhole noise is divided into high-frequency noise and low-frequency noise according to the frequency, high-frequency noise such as hydraulic oscillator noise, low-frequency noise such as rotary motor, drilling mud pump noise, etc.

The hydraulic oscillator is divided into pulse stub and oscillation stub. The pulse nipple is composed of a single screw and an eccentric valve. Taking the drilling fluid as the power source, the periodic change of the channel area is controlled by the pressure control mechanism to convert the hydraulic energy into high-frequency pressure pulse. The oscillating nipple is composed of disc springs in series. The high-frequency pressure pulse pushes the tool body

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

down and compresses the disc spring. After the high-frequency pressure pulse is released, the disc spring drives the tool body to move up, resulting in axial high-frequency vibration. Through axial high-frequency vibration, the static friction between drill string and borehole wall is transformed into dynamic friction to reduce friction resistance; It can effectively improve the WOB transmission in the process of sliding drilling, ensure the stability of the tool surface, reduce the friction between the drilling tool and the borehole wall, reduce the torsional vibration of the drilling tool, and improve the efficiency of sliding drilling. At present, it has been popularized and applied on a large scale in the X oil field of Bohai Sea. However, when the high-frequency pressure pulse generated during the operation of the hydraulic oscillator coincides with the decoding frequency of MWD, it will seriously interfere with the real-time signal transmission of LWD and disturb the transmission and decoding of real-time signal of LWD.

The working principle of the rotary motor is that when the drilling fluid enters the tool to drive the motor rotor in the directional power mechanism to rotate, the power will be transmitted through the transmission shaft assembly to drive the vibration impact assembly to impact the hammer body to move back and forth. Under the action of the pressure difference on both sides of the impact hammer body, the tool generates circumferential vibration shock and hydraulic pulse, which are transmitted to the bit through the internal pressure and torque transmission mechanism, so as to increase the rock breaking efficiency of the bit and improve the mechanical penetration rate. The vibration shock generated by the operation of the rotating motor will also produce a low-frequency pulse signal. When the pulse signal frequency coincides with the decoding frequency of the real-time signal of LWD, it will also interfere with the real-time signal transmission of LWD and affect the transmission and decoding of the real-time signal of LWD.

The drilling mud pump is the key equipment for outputting drilling fluid in the supporting equipment of the whole drilling rig. During drilling and tripping, it ensures that the drilling fluid in the mud tank can circulate in the wellbore. The drilling mud pump is a reciprocating pump. When the mud pump is working, the connecting rod piston of the liquid delivery end assembly operates continuously to produce pump noise, which is transmitted in the drilling fluid. The level of pump noise is related to the level of drilling displacement. Generally, it is low-frequency noise, which usually has little interference with the real-time signal of logging while drilling.

In the subsequent drilling process of several wells in Bohai x oilfield, the frequency of high-frequency noise and low-frequency noise are monitored in real time through spectrum diagram under different drilling parameters such as displacement and speed, and instructions are sent in time to adjust the decoding spectrum of logging while drilling real-time signal, which ensures the authenticity and accuracy of logging while drilling real-time signal and provides a strong guarantee for drilling safety and reservoir evaluation.

4. CONCLUSION

Logging while drilling instrument can make real-time and dynamic evaluation of downhole drilling conditions and formation by measuring various downhole engineering and geological parameters in real time. The transmission and decoding of real-time signal is particularly key. Through the analysis and monitoring of high-frequency noise and low-frequency noise during drilling operation, find out the appropriate LWD real-time signal decoding band. By sending instructions, it can ensure the authenticity and accuracy of LWD real-time data, and provide strong support for drilling safety and formation evaluation in Bohai x oilfield.

REFERENCES

[1] Yao Liang et al. The Process of High-Data-Rate Mud Pulse Signal in Logging While Drilling System[J]. Mathematical Problems in Engineering, 2020, 2020:1-11.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0057

[2] Information Technology; China University of Petroleum Researchers Describe Findings in Information Technology (The Process of High-Data-Rate Mud Pulse Signal in Logging While Drilling System)[J]. Information Technology Newsweekly, 2020.

[3] Guipeng Mu et al. Analysis and Treatment of Abnormal Logging while Drilling Data[J]. Journal of Innovation and Social Science Research, 2021, 8(2).

[4] Chunxi Zhang et al. Vibration Noise Modeling for Measurement While Drilling System Based on FOGs[J]. Sensors, 2017, 17(10) : 2367-2367.

[5] Lu Chunhua et al. Working mechanism and experimental study of electromagnetic measurement while drilling systems based on a relay station[J]. Geophysical Prospecting, 2021, 69(4) : 878-890.