The Numerical Simulation Studies of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument antennas Testing In The Calibrating Tank

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Abstract : The testing problems for The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in the calibrating tank are studied. The calibrating tank is a testing and calibrating device in which the water solution resistivity can modulate, wherein the calibrating barrel diameter of 3 meters, 4 meters high. Testing The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in the device is simulated and computed by the 3-D numerical simulation software MAXWELL, the testing result and the result calculated by MAXWELL are compared and we can find that the error between them is small. The testing charts for The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in calibrating tank are set up. These charts can guide the instruments testing.

Key words: The calibrating tank, The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument, The MAXWELL simulation software, Testing chart

I. INTRODUCTION

Because the antenna of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument is unsymmetrical , the three-dimensional numerical simulation calculations is needed. 2010,Gao Jie[1-2] had done a detailed analysis of Numerical simulation in electrical logging, he pointed out that the finite element method applicated better in three-dimensional numerical simulation. The Maxwell Ansoft simulation software based the finite element method, it has convenient and reliable mesh generation, post-processing and post-processor. In this paper, the Maxwell Ansoft simulation software is used for calculating problems. Firstly, the simulation results were compared with the analytical solution, error is small; secondly, the simulation results were compared with the testing results that are observed by The electromagnetic wave resistivity logging-while-drilling instruments, error is small; Last, the testing charts in the calibrating tank are drawed.

II. INTRODUCTION

A. The calibrating tank

By putting the electromagnetic wave resistivity logging-while-drilling instruments in the changing conductivity salt test solution in the calibrating tank , we can observe many groups testing results while the conductivity changed like testing in the complex formation. The calibrating tank mainly comprises scale barrel, wooden ladder platform, lifting equipment, solution preparation system. Shown in figure 1. wherein the calibrating barrel diameter of 3 meters, 4 meters high. It filled with saline solution of which the resistivity can be changed by the solution preparation system. The range of solution resistivity is 0.2-2000Ω·m.

When the instruments are testing in the calibrating tank, firstly the instruments antenna testing point must be found, secondly, the relative position between the solution face and the instrument uphole face must be calculated, last, lift the instruments in the calibrating tank by the lifting equipment, note that the instruments antenna must be completely covered by the solution and placed centrally. Connect the cable and computer, open the test software, and test. After the completion of the test, the instrument is hung out, a measurement point of saline solution will be prepared and mixed uniform.

Fig. 1 The calibrating tank

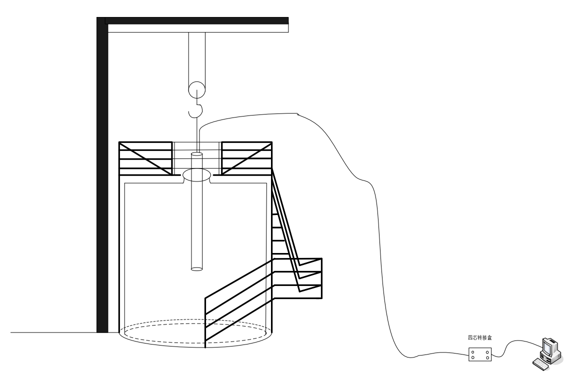

Fig. 2 The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument is working in the calibrating tank.

B. The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument

The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument through the antenna system exciting and receiving high frequency electromagnetic wave. When electromagnetic wave propagats in lossy media, energy will attenuated which causes the phase difference and amplitude attenuation between the two receiving coils[3-4]. The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument uses 2MHz and 400KHz two kinds of frequency, Antenna system uses four transmit（T1、T2*、T3*、T4）and two receive（R1, R2）structure. Shown in figure 3. When testing, T1、T2*、T3*、T4 emit high frequency electromagnetic waves into the formation and the receiving antenna R1、 R2, record their phase difference and amplitude ratio.

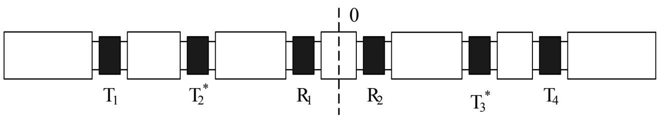

Fig. 3 Antenna system structure diagram of the electromagnetic wave resistivity logging-while-drilling instruments

III. The Accuracy Validation of the Model

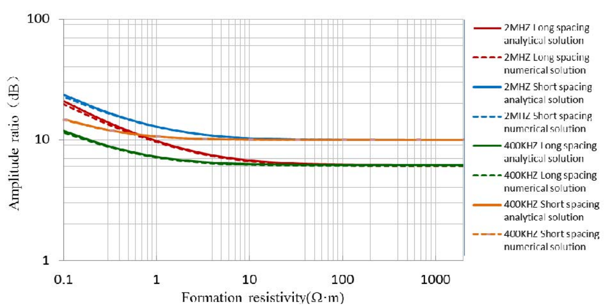

Fig. 4 The contrast of (amplitude ratio) analytical solution and the numerical solution of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument.

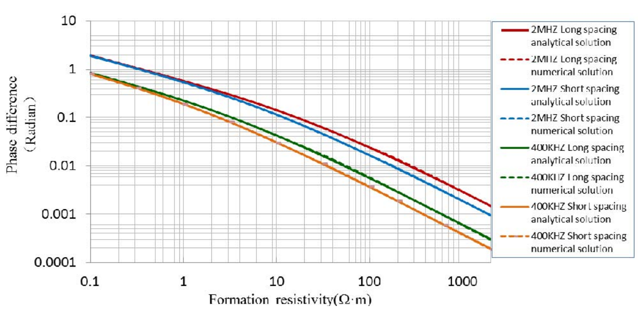

Fig. 5 The contrast of (phase difference) analytical solution and the numerical solution of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument.

In order to verify the numerical simulation accuracy, assume The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument only has antenna system, we can use the analytical method and the finite element numerical simulation method to calculate the numerical solution and analytic solution to compare. Set the homogeneous formation resistivity 0.1 Ω• m ~2000 Ω•m. The transmitting current of 1 A. Shown in figure 4 and 5, the error between the calculated value and the analytical is small, this verify the correctness of the method and program.

IV COMPARING THE NUMERICAL SIMULATION RESULTS WITH THE ACTUAL MEASURED RESULTS IN THE CALIBRATING TANK

Put The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in the calibrating tank and test. The resistivity points of solution in the barrel are 0.34、1.28、5.21、13.28、19.417Ω·m. The actual measurement results and numerical simulation results are shown in Table 1. With the increase of salt water resistivity, amplitude ratio resistivity increases, and deviates from the resistivity points of solution; the phase difference resistivity increases also and resistivity deviates from the resistivity points of solution, but phase difference resistivity deviating from the resistivity points of solution is slower than amplitude ratio resistivity.

Table 1 The comparison of actual measurement results and the results of numerical simulation in the tank

The comparison of actual measurement results and the results of numerical simulation in the tank								
Solution resistivity（Ω·m）	2MHZ short spacing amplitude ratio resistivity（Ω·m）		2MHZ short spacing phase difference resistivity（Ω·m）		400KHZ long spacing amplitude ratio resistivity（Ω·m）		400KHZ long spacing phase difference resistivity（Ω·m）	
	Simulation results	Actual testing results	Simulation results	Actual testing results	Simulation results	Actual testing results	Simulation results	Actual testing results
0.34	0.3401	0.35	0.34	0.35	0.3215	0.32	0.3323	0.34
1.28	1.269	1.29	1.2919	1.36	2.3166	2.27	1.1685	1.22
5.21	6.0086	5.84	4.8777	4.91	22.1517	21.5	7.2426	7.42
13.28	28.9576	30.7	13.6942	14.3	73.843	72	22.8988	22.5
19.417	47.6466	49.7	21.3644	22.8277	110.2376	109.0961	35.2427	34.5092

V TESTING CHARTS

The test charts of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in scale barrel show in Figure 6 and Figure 7, the horizontal coordinate is saline solution resistivity, the vertical coordinate is amplitude ratio resistivity or phase difference resistivity. As can be seen from Figure 6, in the low resistivity region, water resistivity and amplitude ratio apparent resistivity are close, but in the high resistivity region, solution resistivity deviates from and the amplitude ratio resistivity largely. The face made of the 2MHz short spacing curve and 400KHz short spacing curve is similar to the face which is made of the 2MHz long spacing curve and 400KHz long spacing curve.

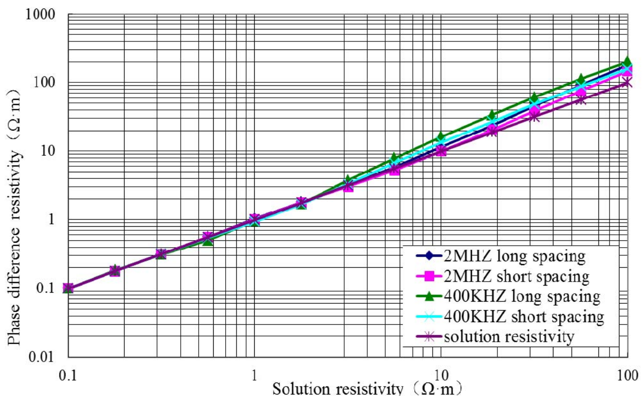

Fig. 6 The amplitude ratio resistivity test charts of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in scale barrel.

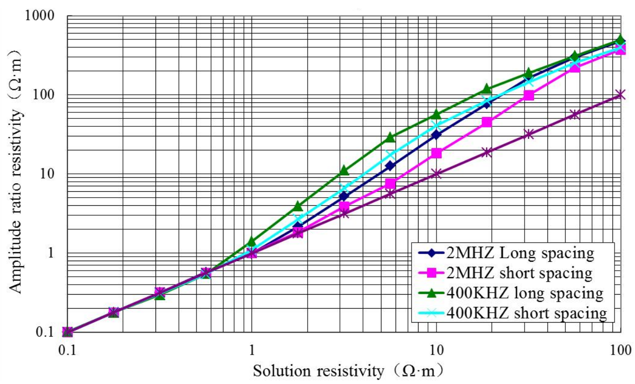

Fig. 7 The phase difference resistivity test charts of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in scale barrel.

VI CONCLUSIONS

(1) Putting The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in the tank for measuring, when in low resistivity, 2MHz and 400KHz amplitude ratio resistivity and phase difference resistivity are approximate with saline solution resistivity, with the salt solution resistivity increasing, amplitude ratio resistivity and phase difference resistivity deviate from the saline solution resistivity, and, the amplitude ratio resistivity deviates faster and greatly.

(2) By test charts of The Electromagnetic Wave Resistivity Logging-While-Drilling Instrument in tank, the arbitrarily saline solution resistivity values can be through interpolation in the chart to find the ideal value measurement. And then compared with the actual measured value, the allowable error within ± 5%, by this way, the instrument stability is confirmed.

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