P076 A NEW APPROACH FOR FAST FORWARD MODELLING OF EM LOGGING DEVICES

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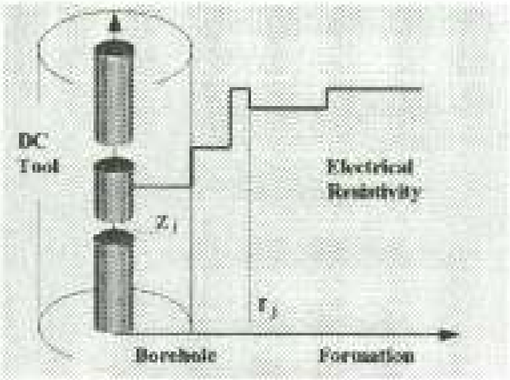
Introduction

All known the inversion efficiency is determined by three general factors – performance of forward problem code, quality of information analysis for interpretation model and optimization scheme technique.

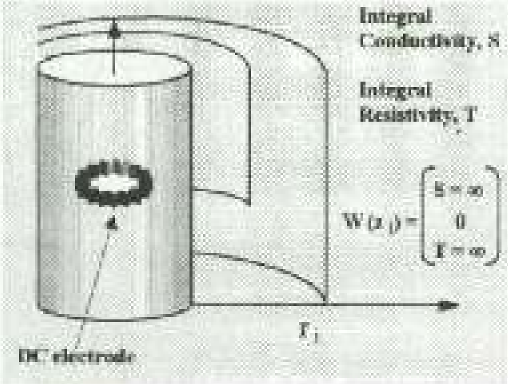
The multiple use of forward problem calculations in information analysis and inversion makes great demands of characteristics of appropriate program code. Up to recent time the fulfillment of such conditions has been able for one-dimensional real time interpretation only. So, the restoration of 1D cross-section takes overpowering part of modern processing in electromagnetic well logging. Nowadays, the first 2D real time inversion systems appear for concrete EM logging technology (Tabarovsky and Rabinovich, 1996).

The present paper deals with the use of specific features of mathematical analysis for forward modeling of direct current (DC) and induction tool responses. We consider three two-dimensional model situations with axial symmetry of medium and instruments. Here statements are formulated for most general models.

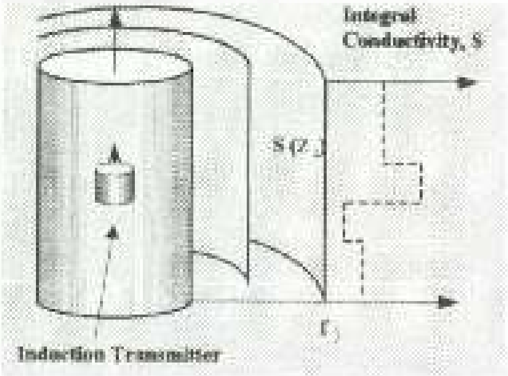
Theoretical models



1. Medium has piecewise uniform radial distribution of electrical resistivity, which can be tensor in each cylindrical layer. Tool includes a set of excitation and measurement sensors of finite sizes (for example, axial surface electrodes of various DC tools).



2. Medium contains a set of cylindrical envelopes with piecewise uniform distribution of shielding electrical property ("reflecting", "transparent" and "absorbing" thin sheet). The source of incident direct current is point or circular electrode. This synthetic model is a basic for development of physical substantiation and numerical algorithm.



3. A few cylindrical surfaces of heterogeneous integral conductivity are placed in surrounding formation. Excitation device is point or finite induction transmitter producing axial magnetic field. The primary current changes due to harmonic or transient regime. Model is oriented to study problems dealing with casing and metrology of logging instruments.

The method

As traditional approach we used advanced techniques of integral equation and finite element methods. But on this way it is impossible to obtain significant progress in performance of algorithm. Besides that it is known great difficulties for numerical evaluation are to take an account of edge and tip influences.

At physical background we divide total quasi-stationary field to normal, geometrical and diffraction parts. Here we use wave theory terms. On a stage of standard integral-differential statement we employ Riemann value boundary problem method. In western literature it is called as generalized Wiener-Hopf method (Weidelt, 1983). The solution of Riemann problem is reduced to computing of vector-function **X** having specific analytical property:

$$\mathbf{X}^{+}(\xi) = \mathbf{G}(W(z_i, r_j), \xi)\mathbf{X}^{-}(\xi) + \mathbf{g}(\mathbf{R}_0, \xi)$$

$$\mathbf{X}(\xi) = \mathbf{X}^{+}(\xi) + \mathbf{X}^{-}(\xi)$$

Where

ξ - spatial frequency of integral transform,

$\mathbf{R}_0\{r_0, z_0\}$ - effective vector-radius of excitation device,

$W(z_i, r_j)$ - information dealing with electromagnetic structure of model.

The dimension of **X** is equal to a number of all edges (special lines of jump-like changes of electrical properties. Expressions of resultant responses have closed integral forms. Determined analytical features of kernel permit to deform integration contours in preferable one for fast computing (Epov and Cheryauka, 1991).

Results & Discussion

General result of our research is the employment of original mathematical method to fast forward modeling of responses of EM logging devices. Results of first numerical experiments for a set of Laterolog and Induction Logging models confirm high efficiency of developed approach.

The significant feature of numerical-analytical method is possibility to reduce approximations with controlled accuracy and to use methods of edge wave theory.

Acknowledgements

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