A New Algorithm for Drilling Twin Parallel Horizontal SAGD Wells based on the Rotating Magnetic Field

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Abstract: 1. objective: The algorithm present has the restrict of interval, thus the writer propose another algorithm to make the system consummate. 2.Methods: Anatomazing the models which put forward by the pioneers and , the writer deducd another equation which can meet the shortage properly. Processing the signal by spectral modification as well. For higher precision, we make a multivariate nonlinear regression at last. 3. Results: The system of RMRS become more perfectly. 4. Conclusion: The more efficient algorithm can emancipate workers from complicated operations with higer precision. What's more, it only need a set of fluxgate sensors. The range of measurement grown a lot when the signal is effective at space.

Keywords: RMRS; MAGD; spectral modification; multiple nonlinear regression;

I. INTRODUCTION

The heavy oil has the characteristic of dense thus we should exploit it by a special craft. The SAGD has become a reliable technology to drill it after application and extension for more than 30 years. [1]The prime technical requirement of twinwells' trajectory is a certain vertical interval about 1m and the relative azimuth angle error should control in +-5°. The system of ranging and guiding based on the rotating magnetic field (RMRS) is a guiding system to control the trajectory[2-3].

The pioneers has present some algorithms of the system of RMRS, but it has some woefully inadequate shortage in practice. For example. In article [4-5], the effective range of the algorithm is truly limited, which is only effective when the test tube is below the magnetic sub[6-7]. In article[8] , it must have two fluxgate sensors in the system. The effective range of the algorithm has enhanced but limited as well. The writer reconstruct the signal models and propose own opinion. However, the algorithm has a restrict of interval after a deep consideration. This word is aiming at put forwod another algorithm to make the system more perfect.

II. THE SIGNAL MODEL OF THE SYSTEM

The fluxgate sensors' model can be shown in figure 1. The writer has reconstruct the signal model in article[9], just as follows:
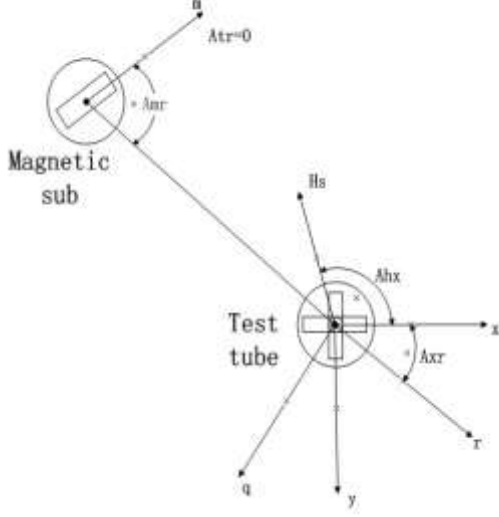

Figure 1. The relative position of twin horizontal wells

$$B_r = \frac{M(2r^2 - z^2)\cos A_{mr}}{4\pi(r^2 + z^2)^{\frac{5}{2}}} \qquad (1)$$

$$B_q = \frac{M \sin A_{mr}}{4\pi(r^2 + z^2)^{\frac{3}{2}}} \qquad (2)$$

$$B_z = \frac{3Mrz \cos A_{mr}}{4\pi(r^2 + z^2)^{\frac{5}{2}}}$$

（3）

$$Bx = \frac{M}{4\pi r^3 (1+\tan^2 \theta1)^{\frac{5}{2}}} \sqrt{\begin{array}{l}(2-\tan^2 \theta1)^2 \\ \cos^2 Axr1 \\ +(1+\tan^2 \theta)^2 \\ \sin^2 Axr1\end{array}}$$

$$\cos(Amr - pa)$$

（4）

$$By = \frac{M}{4\pi r^3 (1+\tan^2 \theta1)^{\frac{5}{2}}} \sqrt{\begin{array}{l}(2-\tan^2 \theta1)^2 \\ \sin^2 Axr1 + (1+\tan^2 \theta1)^2 \\ \cos^2 Axr1\end{array}}$$

$$\cos(Amr - pb)$$

（5）

$$B_z = \frac{3M \tan \theta1 \cos Amr}{4\pi r^3 (1+\tan^2 \theta1)^{\frac{5}{2}}}$$

(6)

Among them, Pa and Pb is the value of difference:

$$cospa = \frac{(2-\tan^2 \theta1)\cos Axr1}{\sqrt{(2-\tan^2 \theta1)^2 \cos^2 Axr1 + (1+\tan^2 \theta1)^2 \sin^2 Axr1}}$$

（7）

$$sinpa = \frac{-(1+\tan^2 \theta1)\sin Axr1}{\sqrt{(2-\tan^2 \theta1)^2 \cos^2 Axr1 + (1+\tan^2 \theta1)^2 \sin^2 Axr1}}$$

（8）

$$cospb = \frac{(2-\tan^2 \theta1)\sin Axr1}{\sqrt{(2-\tan^2 \theta1)^2 \sin^2 Axr1 + (1+\tan^2 \theta1)^2 \cos^2 Axr1}}$$

（9）

$$sinpb = \frac{(1+\tan^2 \theta1)\cos Axr1}{\sqrt{(2-\tan^2 \theta1)^2 \sin^2 Axr1 + (1+\tan^2 \theta1)^2 \cos^2 Axr1}}$$

（10）

$$\frac{(2-x)^2 y + (1+x)^2 (1-y)}{(2-x)^2 (1-y) + (1+x)^2 y} = \frac{|Bx|^2}{|By|^2} \qquad (11)$$

What every symbol's meaning has expressed in article[9].

III. THE COMPENSATORY ALGORITHM TO WORK OUT RELATIVE POSTURE

The writer put forward an algorithm by the relation of phase difference cospa and cospb. However, we anatomize the equation (7) and (9) . Finding that when Axr's value around 0 or 90, the value of sinAxr and cosAxr is about 0. The equations become a ill conditioned equations, which will invalid to work out the relative position in the space or the value is erratic. Just as Table .1 shown. The ideal value of r is 5.

Tabel 1. The result when Axr is around 0° and 90°

A / I / θ	4°	6°	8°	78°	80°	82°
θ1=80° θ2=75°	10.4406	8.5175	7.5812	3.4747	3.1406	2.6573
θ1=75° θ2=65°	7.0286	6.3566	6.0155	4.4510	4.3262	4.1417
θ1=65° θ2=55°	5.2365	5.1265	5.0704	4.7997	4.7755	4.7396
θ1=55° θ2=45°	4.9346	5.0101	5.0517	——	——	——

Tabel 2. The result when the magnetic sub at different posture

Δ / r / θ	4°	6°	8°	78°	80°	82°
θ1=80° θ2=75°	5.0136	5.0200	5.0265	4.9692	4.9747	4.9801
θ1=75° θ2=65°	5.0138	5.0203	5.0270	4.9678	4.9737	4.9794
θ1=65° θ2=55°	5.0183	5.0270	5.0352	4.9626	4.9674	4.9729
θ1=55° θ2=45°	4.9877	4.9791	4.9724	5.0149	5.0129	5.0107

In practice, when facing problem as above, we should find another equation which can include the invalid section. After deduce the model and ongoing trials, we finally put forward the ideal equation. Just as follows:

Set $x = \tan^2 \theta 1, y = \cos^2 Axr1$,

substitute them into equation (7) and (11).

$$\frac{(2-x)^2 y}{(2-x)^2 y + (1+x)^2(1-y)} = \cos^2 Pa = a$$

$$\frac{(2-x)^2 y + (1+x)^2(1-y)}{(2-x)^2(1-y) + (1+x)^2 y} = \frac{|Bx|^2}{|By|^2} = b$$

（12）

$$y = \frac{a(1+x)^2}{x^2 + (6a-4)x + 4 - 3a}$$ （13）

$$(b-1)x^4 + (-8b + 12ab + 2)x^3$$
$$+ (24b - 18ab + 3)x^2 + (-32b + 36ab - 4)x$$
$$+ (16b - 15ab - 4) = 0$$

（14）

The subsequent processure is working out the phase difference and the posture. just as article [9-10], from which we can work out the relative position of the twinwells.

Programming the algorithm after many parameters has been setted. Analysis the method's effective. The results of this algorithm can ben shown in Table 2.
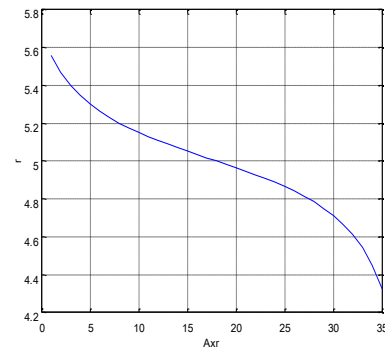

Figure 2. Part of residual error of the algorithm

IV. AMENDING THE MODEL ERROR BY DATA PROCESSING

Seen from the Table .2 we can get the information that the simulation result has certain error from real data. The residual error can be shown in Figure 2. For higher precision, we build the model error. The multiple nonlinear regression is the common method. Generally speaking, quadratic polynomial is enough to meeting the application. In this error model, we set $\tan\theta$ as x1, Axr as x2, y is the value of r. The originally equation is:

$$y = a + b_1 x_1 + b_2 x_2 + b_{11} x_1^2 + b_{22} x_2^2 + b_{12} x_1 x_2 \qquad (15)$$

After the data processing of multiple nonlinear regression, we can get the value of a, b1, b2, b11, b22 and b12. That is:

$$y = 0.006157 + 0.001847 x_1 - 0.00651 x_2 - 0.00012 x_1^2 + 0.000283 x_2^2 + 0.001357 x_1 x_2$$

$$(16)$$

V. CONCLUSION

The system of RMRS has been applied many years. The result of the algorithm shows that the set of algorithm can improve the RMRS's maneuverability go a step further. The precision is enough. It's convenience of operating can economize a lot of money. It has great engineering application value and obvious economic benefit.

VI. ACKNOWLEDGMENT

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