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Unsteady-State Flow Created by a Slanted Well In Coal Mine

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Abstract This paper presents an analysis solution derived to study the unsteady-state hydraulic head created by a slanted well which was drilled from the roof of the tunnel in coal mine, indicates that the slant of a fully penetrating well creates a drawdown that is a function of the angle of slant and the formation thickness.
Keywords slanted well, unsteady-state flow

Introduction

Slanted well which also called as inclined borehole is widely used in coal mine dewatering, it's important to research the equation of inclined boreholes well flow. Hydrogeological experts has proposed "Dupuit steady well flow equation" , "Theis unsteady well flow equation" and other calculation methods, but the borehole must be assumed to be vertical , it does not fit to inclined borehole. In recent years, oil experts derived a analysis of inclined productivity and the pseudo-skin factor based on sources theoretical, hydrogeology experts derived an analysis of horizontal wells flow calculation equation under different hydrogeological conditions based on sources theoretical too. In this study both result are assumed as the basis for the coal mine inclined boreholes flow calculation method .

Single borehole inclination confined aquifer ideal model

In order to derive the analytical solution flow inclined boreholes, this paper attempts to create a three-dimensional conceptual model inclined boreholes in the confined aquifer.

Fig. 1 shows a three-dimensional conceptual model of slanted well in confined aquifer. Assumed to be homogeneous isotropic aquifer. The origin of the coordinate system is located in the midpoint of the projection oblique drilling horizontal position in the floor. As the role of the filter casing and pipes, water drilling guide section can be slanteded at any angle at any position of the aquifer.

Analysis solution of single inclined borehole

The aqueous layer from the lower boundary of the distance measured to the midpoint of the drilling z_w; θ_w represents the angle drilling and horizontal; Observation point P of the spatial coordinates (r, θ, z).

In 1884, L.Kelvin in theoretical studies of the thermal conductivity of a homogeneous isotropic distribution under an infinite medium instantaneous point source space temperature raised a fundamental role in the solution. This solution groundwater wells become an important method for flow - the basis of source and sink method (fig. 1).

Kelvin's solution to broaden the anisotropic medium, in the strength of V_p instantaneous point sink effect, infinite space distribution head drawdown can be expressed as:

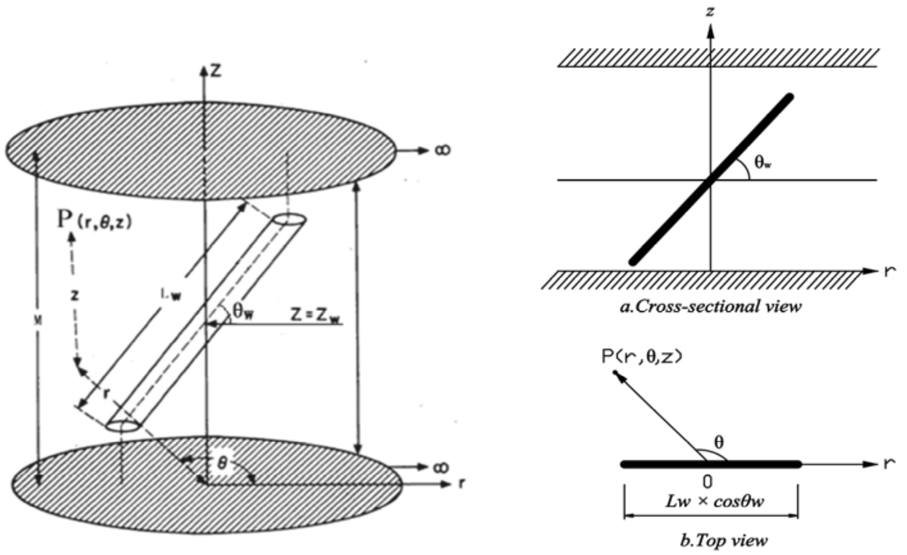

Fig. 1 *Schematic slanted well in confined aquifer*

$$s(r,z,t)=\frac{V_p}{8\mu_s(\pi^3 a_r^2 a_z t^3)^{\frac{1}{2}}}\exp\left(-\frac{\bar{r}^2+(z-z')^2}{4a_z t}\right) \qquad (1)$$

where, s is head down as deep; V_p instantaneous point sink strength, the volume of water that is a point sink instantaneous extraction; μ s increments elastic water level; $a_r = K_{rr} / \mu_s$ for the horizontal direction pressure aquifer conductivity; $a_z = K_{zz} / \mu_s$ for the vertical direction pressure of the aquifer conductivity; t starting from the instantaneous pumping time; Converted into the coordinate of the observation point in the radial coordinate isotropic porous media; r, z coordinates of the observation point; z' is the instantaneous point sink in the z-axis position.

The formula: in an infinite homogeneous anisotropic space (aquifers), in the time $t = 0$, the point (0, z') at a caliper to zero spherical volume V_p groundwater extraction wells instantaneously after that, head (r, z) at the drawdown s. For injection wells, only one of s and V_p were negative value only (fig.2).

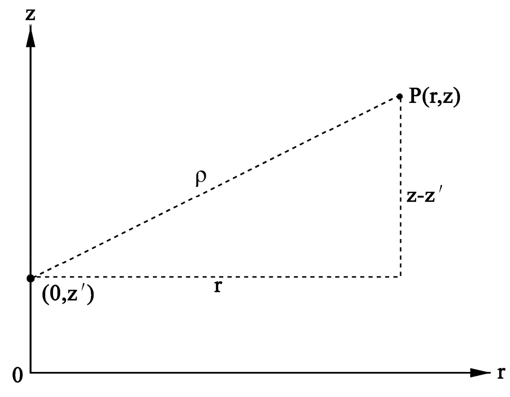

Fig.2 *Meeting space and the instantaneous position of the point of observation points*

Infinite homogeneous anisotropic medium length L_w slanted instantaneous line sink in the infinite space of the cylindrical coordinate analytic formula is:

$$s = \frac{V_L}{8\mu_s(\pi^3 a_r^2 a_z t^3)^{\frac{1}{2}} \sin\theta_w} \int_{z_w - \frac{L_w}{2}\sin\theta_w}^{z_w + \frac{L_w}{2}\sin\theta_w} \exp\left[-\frac{\alpha r^2 + \alpha(z_p - z_w)^2 \cot^2\theta_w - 2\alpha(z_p - z_w)\cot\theta_w \cos\theta + (z - z_p)^2}{4a_z t} \right] dz_p \tag{2}$$

Let length L_w instantaneous line sinks (fig.3) the intensity of Q, the instantaneous intensity of the differential line sinks dz_p for $Q_1 = Q$ / dz_p. Using equation (3) can be written in the differential instantaneous line sinks dz_p (can be regarded as instantaneous telegraphic) role in any spatial point differential drawdown (r, θ, z) Department, The style is the length L_w, the slanted angle of the horizontal continuous line sinks expression θ of analytical solutions.

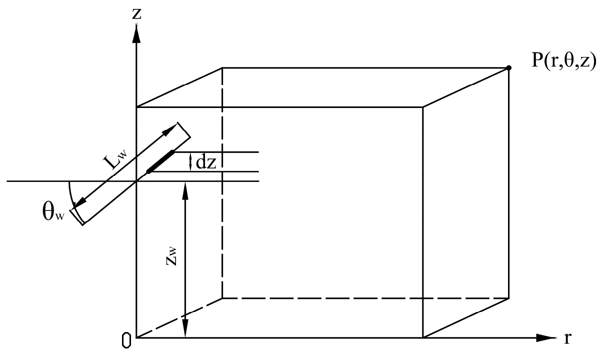

Fig. 3 *Location infinite space aquifer inclined line sink and observation points*

Semi-infinite homogeneous isotropic medium length Lw slanted instantaneous line sink in a semi-infinite cylindrical coordinate space analytic method can reflect the semi-infinite space into infinite space problem(fig.4), the analytical solution is:

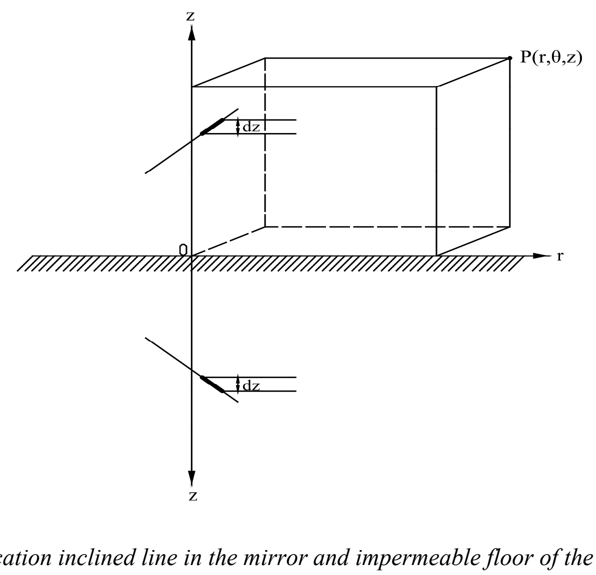

Fig.4 *Meeting location inclined line in the mirror and impermeable floor of the observation point*

$$s = \frac{V_L}{8\mu_s(\pi^3 a_r^2 a_z t^3)^{\frac{1}{2}} \sin\theta_w} \exp\left(-\frac{\alpha r^2}{4a_z t}\right)$$
$$\int_{-\frac{L_w}{2}\sin\theta_w}^{\frac{L_w}{2}\sin\theta_w} \tag{3}$$
$$\{\exp\left[-\frac{\alpha z'^2 \cot^2\theta_w - 2\alpha rz'\cot\theta_w\cos\theta + (z - z_w - z')^2}{4a_z t}\right]$$
$$+\exp\left[-\frac{\alpha z'^2 \cot^2\theta_w + 2\alpha rz'\cot\theta_w\cos\theta + (z + z_w - z')^2}{4a_z t}\right]\} dz'$$

The continuous line sinks role as a series sum of the instantaneous line sink effect. Withdrawals for each instantaneous line sinks on dq = Q (τ) dτ space in a continuous strength for the next Q lines sequestration, deep down at any point s. So, τ moment, in the instantaneous intensity of Qdτ line sequestration, observation points are reflected d$s's$.

$$s(r,\theta,z,t) = \frac{V_L}{8\mu_s(\pi^3 a_r^2 a_z)^{\frac{1}{2}} \sin\theta_w} \int_0^t \frac{\exp\left(-\frac{\alpha r^2}{4a_z(t-\tau')}\right)}{(t-\tau')^{\frac{3}{2}}}$$
$$\sum_{n=-\infty}^{\infty} \{\int_{-\frac{L_w}{2}\sin\theta_w}^{\frac{L_w}{2}\sin\theta_w} \tag{4}$$
$$[\exp\left(-\frac{\alpha z'^2 \cot^2\theta_w - 2\alpha rz'\cot\theta_w\cos\theta + (z + 2nh - z_w - z')^2}{4a_z(t-\tau')}\right)$$
$$+\exp\left(-\frac{\alpha z'^2 \cot^2\theta_w + 2\alpha rz'\cot\theta_w\cos\theta + (z + 2nh + z_w - z')^2}{4a_z(t-\tau')}\right]\} dz' d\tau'$$

For τ from 0 to t points can be continuously pumped at any point of time t drawdown that Confined aquifer system is up and down on the roof watertight type, the length of L_w, the slanted angle of the horizontal continuous line sinks expression θ of analytical solutions.

Conclusions

In this paper, the level of homogeneous anisotropic confined aquifer full slanted drilling wells unsteady flow calculation equation was derived; Stabilized flow in inclined boreholes approximate calculation equation is derived; The applicability of the formula based on the coal mine water drainage test instances was verified. The results will help the coal mine water drainage design and construction work of drilling and related norms, standards.

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