Non-steady flow to a well of constant drawdown in an intrusive dike

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The dikes are a sheet of rock that form in a fractures of a pre-existing rock body. They may be of magmatic or sedimentary origin. The thickness of the dikes can range from several meters to several tens of meters, while their horizontal extent can reach several kilometers.

When massive dikes are fractured, they can be very permeable and may form promising sources of water, especially where the country rock is low productivity. The high permeability dike, together with the low permeability surrounding rock, forms a composite dike-aquifer system. Conventional well-flow models cannot be used to analyze pumping tests in such systems. When the well in the dike is pumped at a constant rate, three characteristic flow periods can be distinguished: linear flow at early times, bi-linear flow at medium times, and pseudo-radial flow at late times. The hydraulic behavior of composite dike-aquifer systems is identical to that of single-fracture aquifer systems.

In previous work by the author [1], analytical models were developed to evaluate the flow rate of vertical well with finite conductivity fracture when a well is produced at a constant pressure. In this work we summarize these analytical models and extend their application to composite dike-aquifer system.

Analytical solution:

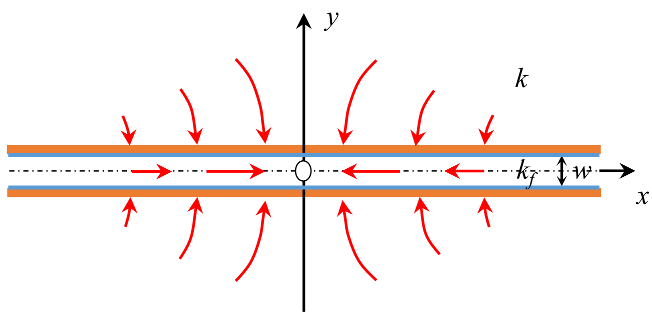
$$\bar{Q}_d(u)=\frac{\sqrt{1+u}}{u\left(\beta\operatorname{cth}\beta+(\pi-\alpha)\operatorname{ctg}\alpha\right)}, \qquad (1)$$

u – Laplace transform variable,

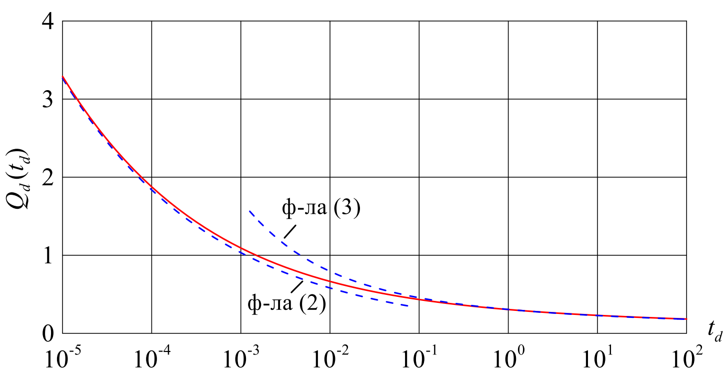
$$\alpha=\arccos A,\quad \beta=\arccos B,\quad A=\frac{\sqrt{1+u}-1}{\sqrt{u}},\quad B=\frac{\sqrt{1+u}+1}{\sqrt{u}}$$

$$Q_d=\frac{Q(t)}{2\pi kbs}$$ – dimensionless flow rate,

$$t_d=\frac{k^3 t}{S_s k_f^2 w^2}$$ – dimensionless time.



w – dike width, b – aquifer thickness,
s – water level, S_s – specific storage,
$k,\ k_f$ – hydraulic conductivities of aquifer and dike.



Dimensionless flow rate of a well in a dike.

Bi-linear flow period:

$$Q_d(t_d)=\frac{\sqrt{2}\,t_d^{-\frac{1}{4}}}{\pi\Gamma\left(\frac{3}{4}\right)} \qquad (2)$$

Pseudoradial flow period:

$$Q_d(t_d)=\frac{1}{\ln\left(1+\pi\sqrt{\pi t_d}\right)} \qquad (3)$$

1. Морозов П.Е. Моделирование нестационарного притока жидкости к вертикальной скважине с поврежденной трещиной ГРП // XIII Всероссийский Съезд по теоретической и прикладной механике, Т.4. – СПб.: Политех-Пресс, 2023. С. 391-393.