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Determining the Transmissivity of the Artesian Aquifer By the test Data of the Flowing Wells

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Abstract

The article considers the method of determining the transmissivity of the artesian confined aquifer by using the results of the flow measurement of the flowing wells that were conducted at two different time intervals. The suggested method is based on the design formula which has been earlier got by the author for the single flowing well. Herein the complexities are overcome which are associated with the monotone reduction of the flows and pressures of such wells over time, and also hydraulic resistances generating in them. The checkup of the suggested method by the data of the field observations has yielded satisfactory results.

Keywords: Transmissivity; Flowing Well; Hydraulic Resistance; Artesian Aquifer; Hydrogeological Parameters

Introduction

Currently, the methods of data processing of the experimental pumping from the vertical wells are mainly based on the theory of the unsteady filtration (permeability) mode which for determining hydrogeological parameters of aquifers allows using the data about the groundwater level decline over time in the observation wells, or in the water intake well at its time-constant flow rate [1,2].

Materials and Methods

By this well-known enough method, except maybe [3], it is rather difficult to calculate with the necessary accuracy the hydrogeological characteristics of the artesian elastic aquifer by the data of operations of the flowing wells. The latter ones obtain the peculiarity-their flow rate and drawdown simultaneously change over time, and downhole hydraulic resistances play great role at the flow rate formation. At the absence of the observation wells, which is true almost for all flowing wells on the Ararat valley, the solution of the assigned task by the known standard methods becomes more difficult. And the absence of observation (unproductive) wells on the Ararat valley is associated with deep location of artesian confined aquifer at which boring of these wells is very expensive. Currently on the Ararat valley, for water supply and irrigation, there are over 900 operating flowing wells without availability of observation network which provides necessary information about drawdown in the artesian aquifer, the parameters of which shall be often determined for different hydrogeological calculations of water intake structures. In the work [4] the author presents the solution of the problem by the data of single measurement of the flow rate of the well, but this solution at its engineering use causes some difficulties, at the same time being vulnerable regarding full-scale measurement of the flow rate.

In the suggested method these shortcomings are resolved. Herein, the author gives the method of determining the transmissivity of the artesian elastic aquifer based only on the information about its parameters and values of the well flow rates measured at two quite separate points of time.

The method is based on the formula obtained by us for determining the flow rate of the flowing well at any moment of time [4]. These wells have the peculiarity-their flow rate and drawdown simultaneously monotonously reduce over time, and formation of their flow rate is equally influenced either by hydrogeological parameters of the aquifer or parameters of the wells themselves [5].

This formula has the following form:

$$Q = \frac{4\pi T H_p}{Ln\frac{2.25\alpha t}{r_o^2} + 2\xi_{imp} + 4\pi T\eta Q} \quad (1)$$

where Q-flow rate at any time moment, T = km-transmissivity, k-filtration coefficient of the layer, m-its thickness, H_p-initial positive piezometric head in the layer, α-the coefficient of its piezoconductivity, r_o-well radius, ζ_{imp}-its imperfection coefficient of well, η-total resistance of the well.

Modification to the equation (1) for determining $Ln2.25\alpha t/r_o^2$ leads to the view:

$$Ln\frac{2.25\alpha t_i}{r_o^2} = 4\pi T\left(\frac{H_p}{Q_i} - \eta_i Q_i\right) - 2\xi_{imp} \quad (i = 1;2) \quad (2)$$

By writing the equation (2) for the measurements at two moments of time: t_1 and t_2, and by subtracting first from the second, for calculating transmissivity T of the aquifer, we get the following dependency:

$$T = \frac{Ln t_2/t_1}{4\pi\left[H_p\left(Q_2^{-1} - Q_1^{-1}\right) + \eta_1 Q_1 - \eta_2 Q_2\right]} \quad (3)$$

As our preliminary calculations showed, usually in the prolific flowing wells, the water moves in the quadratic zone of resistance where the total hydraulic resistance of the well η can be accepted with the great accuracy in t_2 - t_1 time interval as a constant value i.e $\eta_1 = \eta_2$. Keeping this in mind, from the formula (3) we get the formula for calculating T in more convenient form:

$$T = \frac{Ln t_2 t_1^{-1}}{4\pi(Q_1 - Q_2)\left[\frac{H_p}{Q_1 Q_2} + \eta\right]} \quad (4)$$

Illustration and checkup of the suggested method is done by the example of the well 121[b] of the PNIIIS (Production and Research Institute for Engineering Surveys in Construction), bored on the area of village Kharatlu-Aghamzalu of the Ararat valley. The initial data are the following:

Positive head on the wellhead H_p = 18.65 m, the total length of the well ℓ = 98 m, the length of filter ℓ_f= 34 m, well radius r_o = 0, 1778 m, total resistance of the well η = 1.242 · 10-8 day2/m5, at t^1 = 1 day well flow rate Q_1 = 582 l/s, and at t_2 = 7 days: Q2 = 550 l/s.

Then, for T by formula (4), we get T = 5594 m^2 /day.

From the reports of the PNIIIS [6], for the given well the value is brought k = 133 m/day, and m = 50 m, that is T = 6665 m^2 / day, it means that the deviation makes 16 %, which is quite permissible, especially if we consider that while determining the filtration coefficient until now considerable deviations from that have been accepted.

Conclusion

At complicated hydrogeological conditions, for more precise calculations of values of hydrogeological parameters, including conductivity of the artesian aquifer we suggest using developed at that inverse problem.

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