Application of Aquifer Test Software in Calculating Hydrogeological Parameters according to the Data of Pumping Test

[1, 2]Zhang Zhihua, [3]Tang Hui

[1]School of Environmental Science and Engineering, Chang'an University, No.126 Yanta Road, Xi'an 710054, China

[2]Key Laboratory of Subsurface Hydrology and Ecology in Arid Areas, Ministry of Education, No.126 Yanta Road, Xi'an 710054, China

[3]Survey and design institute of mechanical Industry, Xi'an, China

Abstract: ***According to the site catalog data of pumping, the hydraulic conductivity in Hua county water source was determined by using the Aquifer Test 4.2 software and on the basis of imitation of Theis formula, Neuman model and Boulton model. And the value of hydraulic conductivity with three methods and the average value is 12.15m/d, 9.5m/d, 9m/d, 10.22m/d, respectively. The analysis demonstrated that Newman method is more suitable than imitation theis method and Bolton method for calculation the hydrogeological parameters of phreatic aquifer in study area.***

Keywords: aquifer test, pumping test, hydraulic conductivity, transmissivity

1. Introduction

Transmissivity (T) and hydraulic conductivity (K) are the important hydrogeological parameters for the calculation and evaluation of groundwater resources, groundwater flow numerical simulation and forecast. There are a lot of methods for determining these parameters. Qiu Jinfeng acquired the aquifer hydrogeological parameters through a pumping test in a porous aquifer near an oil field, by using MODFLOW software[1] (2006). Liang Xiujuan put forward a new method for calculating parameters with dynamic data. This method is used to determine the parameters of the aeration zone and fluctuation zone of groundwater stage when the groundwater depth is large [2] (2000). Shi Zhiyuan obtained hydrogeological parameters through genetic algorithm with pumping test and compared the parameters with that of wiring method and direct graphic method. Results show that computing drawdown of request parameters obtained by genetic algorithm matches with the actual drawdown of request parameters [3] (2011). Based on the Theis formula of aquifer pumping test, optimization theory and computer technology, Xiao Changlai proposed entirely fitting curve method which pumping test data are used to determine the aquifer parameters[4](2005). At present, the pumping test method is the main method to determine the parameters of the aquifer. In these methods, the steady method and transient flow method can be used in calculating the parameters of phreatic water. The Dupuit and Thiem formula are adopted by phreatic water steady well flow, and the imitation of Theis formula, Boulton model, Neuman model, the water stage recovery method are applied into partially penetrating well flow.

Due to subjective reasons, the results might not be the same when traditional methods were used to calculate the parameters of pumping test at the same wellhole by different people. Because there is no formulaic answer and no unique answer, so it makes the judgment more difficult. Thus, the accuracy and reliability of the aquifer parameters may be affected. So obtaining parameters with computer automatically becomes widely used. It possesses the advantages of fast speed, high efficiency and accuracy, and good comparability. Currently, Aquifer Test software which calculates the parameters of the pumping test by computer is developed by Waterloo Hydrogeologic Incorporated [5] (2011). This software is specifically used for the analysis of data of pumping test, data processing, analysis and research of obtaining parameters graphically. It can be applied to calculate the data of pumping test and complete the display and printing of the process and result of getting parameters.

The conductivity was determined by using the Aquifer Test 4.2 software and on the basis of imitation of Theis formula, Neuman model, Boulton model by using the data of pumping test in a phreatic aquifer of Hua county water source.

2. Data of Pumping Test

Multiple wells unsteady-flow pumping test proceeded in a phreatic aquifer at the water source, Hua County, Weinan City, China. Pumping wells numbered P1, depth of 45m, hole diameter of 0.11m; Observation well 01#, depth of 45m, hole diameter of 0.11m, distance from pumping well r_1=3m. The steady flow of the pumping well is 1200m^3/d. According to the site catalog data, the aquifer thickness M= 40m, and the initial static water level is 4.2m. The pumping test runs 11430 minutes. While pumping, the observation data of observation well 01# is shown as figure 1.

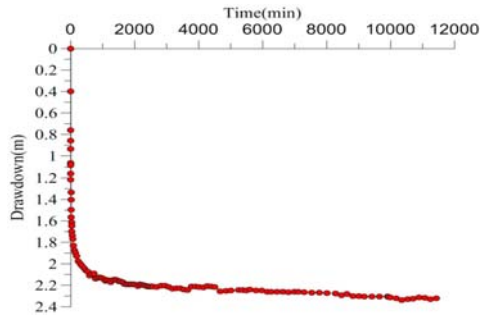

Figure 1: Time-drawdown figure curve at observation well 01#

3. Determine parameters with Aquifer Test 4.2

Two complete wells were set up in Aquifer Test 4.2. Specific settings of each well were shown in figure 2. Select constant in Discharge window and type 1200; select 01# in Water Levels window and type the data of time-drawdown. Then select these three solving methods, Theis with Jacob correction, Neuman, Boulton, and type-curve with professional judgment.

	Name	Type	X [m]	Y [m]	Elevation (a	Benchmark [	Penetration	R [m]	L [m]	b [m]	r [m]
1	P1	Pumping Well	0	0	0	0	Fully	0.15	30	45	0.11
2	01#	Observation Well	0	3	0	0	Fully	0.15	30	45	0.11

Figure 2: Details for each well in pumping test

3.1 Determine the parameters on the basis of Theis with Jacob correction

Fit curve by choosing Theis with Jacob correction in the Analysis window. Adjusted curve is shown in figure 3. The result of the type curve is: $T=4.86\times10^{2}(m^2/d)$, and the calculated value of K is 12.15(m/d). Fitting correlation coefficient is 0.965.

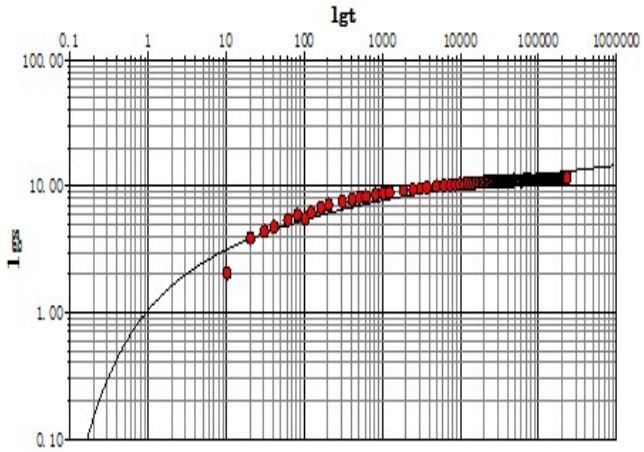

Figure 3: Fitting curve use Theis with Jacob correction at observation well 01#

3.2 Determine the parameters on the basis of Neuman formula

Fit curve by choosing Neuman in the Analysis window. Adjusted curve is shown in figure 4. The result of the type curve is: $T=3.80\times10^{2}(m^2/d)$, and the calculated value of K is 9.5(m/d). Fitting correlation coefficient is 0.997.

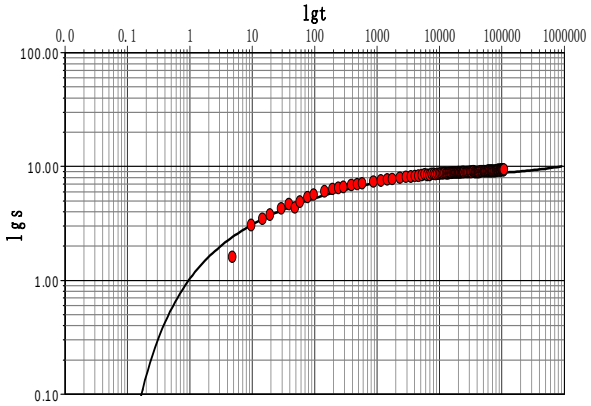

Figure 4: Fitting curve use Neuman at observation well 01#

3.3 Determine the parameters on the basis of Boulton formula

Fit curve by choosing Boulton in the Analysis window. Adjusted curve is shown in figure 5. The result of the type curve is: $T=3.60\times10^{2}(m^2/d)$, and the calculated value of K is 9(m/d). Fitting correlation coefficient is 0.976.

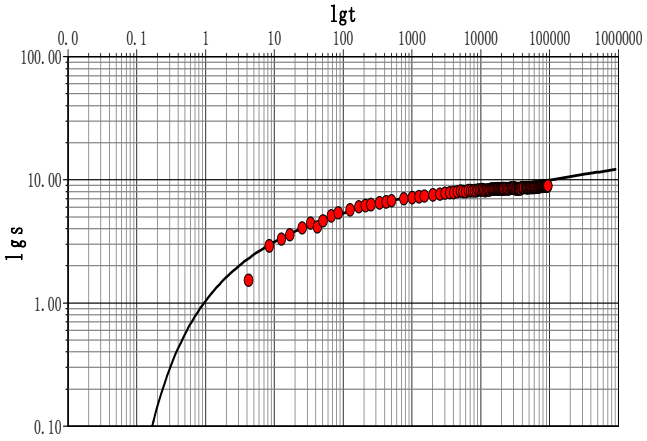

Figure 5: Fitting curve use Boulton at observation well 01#

4. Results and Discussion

For the imitation of Theis formula of phreatic water complete well, its advantages are the sample and convenience within derivation and put into use. But its drawback is also significant. Firstly, the solution of imitation Theis well flow model is derived under the assumption that the specific yield μ and conductivity coefficient T are constant. But the actual situation is that the specific yield μ varies with time and conductivity coefficient T varies with the thickness of the aquifer. So there will be some discrepancies between the hydrogeology parameters calculated by the imitation of Theis well formula and the actual situation. The Newman well formula requires the phreatic aquifer homogeneous, anisotropic, and constant gravity specific yield. Vertical seepage velocity and elastic release were concerned. And the "lagging water supply" was replaced by "groundwater level lag response". The Bolton well formula requires the phreatic aquifer homogeneous and isotropic. Vertical seepage velocity was ignored and the gravity specific yield was considered as variable. Gravity lags water supply and elastic release were also concerned. Combined with the aquifer media of this water source, the previous research results and the hydrogeology parameters calculated by the three methods, the result can be obtained that the aquifer medium of study area is not isotropic after the analysis of variation law of parameters and the trends of fitting curves. In addition, time used by gravity lag water supply is shorter in the three stages of drawdown in pumping test which is shown in figure 5. Therefore, to some extent, gravity lag water supply concerned by Bolton method can be approximately handled by using water table lag reaction of Newman method. In summary, the Newman method is more suitable than imitation of Theis method and Bolton method for calculating the hydrogeological parameters of phreatic aquifer in the study area. In order to obtain a more accurate parameter, the hydraulic conductivity got by the three methods was taken average and the value is 10.22 m/d.

References

[1] J.F. Qiu, Z.G. Zhan, S. Liu, “The application of Modflow in solving hydrogeological parameters,” Chian Water Transport, 4 (12), pp. 50-51, 2006.
[2] X.J. Liang, C.L. Xiao, H.S. Liu, “Study on Calculation of Hydrogeological Parameters with Method of Dynamic Data Analysis,” Jilin Water Conservation, 5, 2000.
[3] Z.J. Shi, M. Xu, “Hydrogeological Parameter Inversion by Genetic Algorithms Based on Pumping Test,” Acta Geologica Sichuan, 31(4), pp. 446-480, 2011.
[4] C.L. Xiao, X.J. Liang, J.M. Cui, Y.Y. Lan, J.Zhang, C.L. Li, R.Q. Liang, C. Zheng, “Whole Curve Matching Method for Aquifer Parameters Determination,” Journal of Jilin University(Earth Science Edition), 35(6), pp. 751-755, 2005.
[5] H. Jiang, “An analysis of parameter calculation through pumping tests based on the Aquifer Test,” HYDROGEOLOGY & ENGINEERING GEOLOGY, 38(2), pp. 35-38, 2011.

Author Profile

Zhang Zhihua received bachelor degree from Chang'an University in 2011, now studying at the Graduate School of Chang'an University, China.

Tang Hui received master degree from Chang'an University in 2013, now working at the Survey and design institute of mechanical Industry, Xi’an, China.