A new semi-solution for variable-rate pumping test in a leaky aquifer with a finite-thickness skin

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Abstract

Pumping test has been commonly used to estimate aquifer parameters in the field work. The classical pumping tests can be classified into two general types: i.e. constant-rate pumping test or the constant-head test pumping test. However, the pumping rate might be variable under certain circumstances. In this paper, we developed a new model of an exponentially decayed-rates pumping test in an aquitard-aquifer system with considering a finite-thickness skin effect. A semi-analytical solution was obtained in Laplace domain and then it was inverted numerically with the Stehfest method. The solution of this study can be simplified to the solution of Wen et al. (2017) and Yeh et al. (2003). The results indicated that the drawdowns approach the same asymptotic values as those of the constant-rate pumping test at early and late times, while they decrease for a short period at intermediate times in the region near the pumping well. The existence of aquitards made the drawdowns stable earlier and a larger transmissivity of aquitards leads to a smaller drawdown in aquifer. The well skin has great impact on the drawdown values in the skin zone, while it has no impact on the drawdown values in the formation zone. A thicker skin results in a larger drawdown for the positive skin case while it leads to a smaller drawdown for the negative skin case. The results of this study will provide some new insights for parameters estimation and the design of a pumping test. The proposed model has been applied to estimate the aquifer parameters by using the particle swarm optimization in Jianghan plain associated with the field pumping test data.

Key words: Variable-rate; Pumping test; Skin effect; Aquitard-aquifer system; Laplace transform