Simulation of Pumping Induced Groundwater Flow in Unconfined Aquifer Using Arbitrary Lagrangian-Eulerian Method

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Introduction:
The conventional approach (following the Dupuit assumption) for characterizing groundwater flow in unconfined aquifer is restricted when complex physics is applied. A new simulation method is introduced and tested by comparing the model results with the analytical solution. Model development is accompanied by conducted field tests.

Computational Methods:

➢ Steady State

• Darcy's Law:

\[ \nabla (\rho u) = 0 \quad u = \frac{K}{\mu} \nabla p \]

• Thiem Equation:

\[ h(r) = h_0 - \frac{Q}{\pi K} \ln \left( \frac{r}{r_0} \right) \]

➢ Unsteady State

• Darcy's Law:

\[ \rho \frac{\partial h}{\partial t} + \nabla (\rho u) = Q_{\text{in}} \]

Results:

➢ Simulation results coincide well with analytical solution.

➢ The position of groundwater table can be tracked with moving mesh method.

➢ The observed vertical variance of hydraulic heads in the vicinity of pumping well can be simulated with the method.

Boundary Conditions:

➢ Top: groundwater table moves when the borehole is pumped constantly.

➢ Bottom: impermeable aquifer bottom, no flow condition applied.

➢ Left: groundwater abstraction.

➢ Right: pressure constrain.

Figure 1. Borehole and observation set-up at Plötzin test site

Figure 2. Concept and boundary set-up

Figure 3. Groundwater table tracked via moved mesh

Figure 4. Numerical simulation vs. analytical solution

Figure 5. Vertical variation (Field test calibration result) of hydraulic heads (r=1m)

Conclusions:

➢ The good verification test result gives indications for the model reliability.

➢ A promising further application future is expected due to the model flexibility, in terms of coupling with other physical processes and application of complex boundary conditions.

➢ The limitation and difficulty of the model is the choice of model region in order to avoid the outer boundary influence.

Links:

1. Geoscience Center Georg-August University: http://www.uni-goettingen.de/de/8483.html

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