Modeling a Nozzle in a Borehole (2)

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Introduction: Within boreholes nozzles have to be found advantageous to increase the infiltration of water into the subsurface ground. Studies and practice in the field shows that the infiltration of water into permeable aquifers can be improved, if the flow in the borehole is modified. Due to the nozzle the flow regime turns from laminar to turbulent. CFD studies help to understand the physics of the infiltration process. The transition of the flow regime within the borehole and its further effects on flow within the porous medium of the aquifer was examined using COMSOL Multiphysics.

Figure 1. Injection (recharge) well;
ground view (left), look inside top (center), scheme (right)

Computational Methods: We report about numerical experiments with slightly turbulent flow, as observed in the nozzle. Two options of turbulent flow modeling, Navier-Stokes k-ω and k-ε, were tested. Mesh refinement and boundary layer options were studied in addition. From the experiences in a simplified geometry we draw conclusions about best modelling options.

We used a simplified 2D approach, converting the filter holes into filter slices. In the modelled design the filter consists of 9 slices. We included the porous ground surrounding the lower borehole in the model (Figure 2)

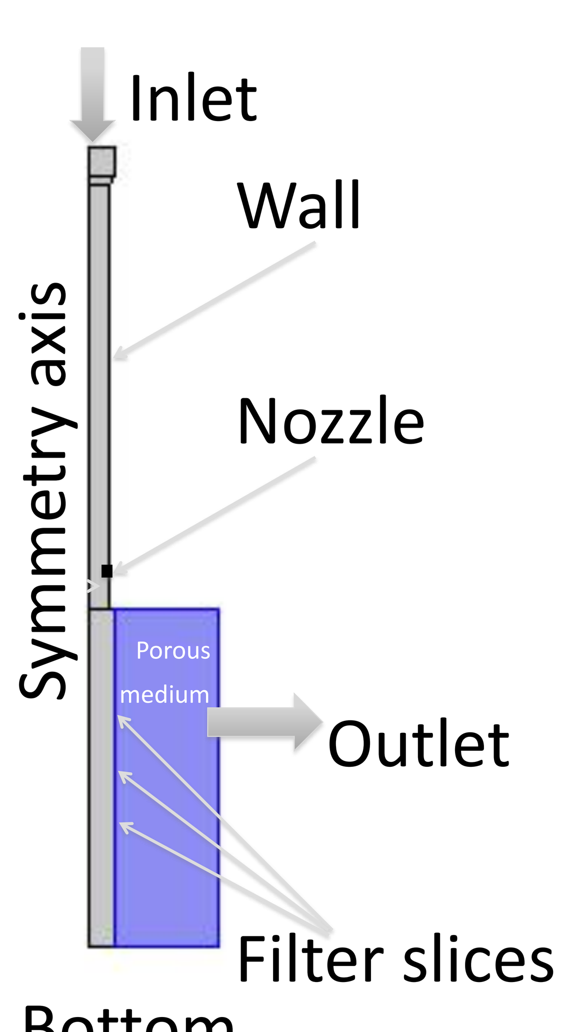

Figure 2. Coupling with porous medium

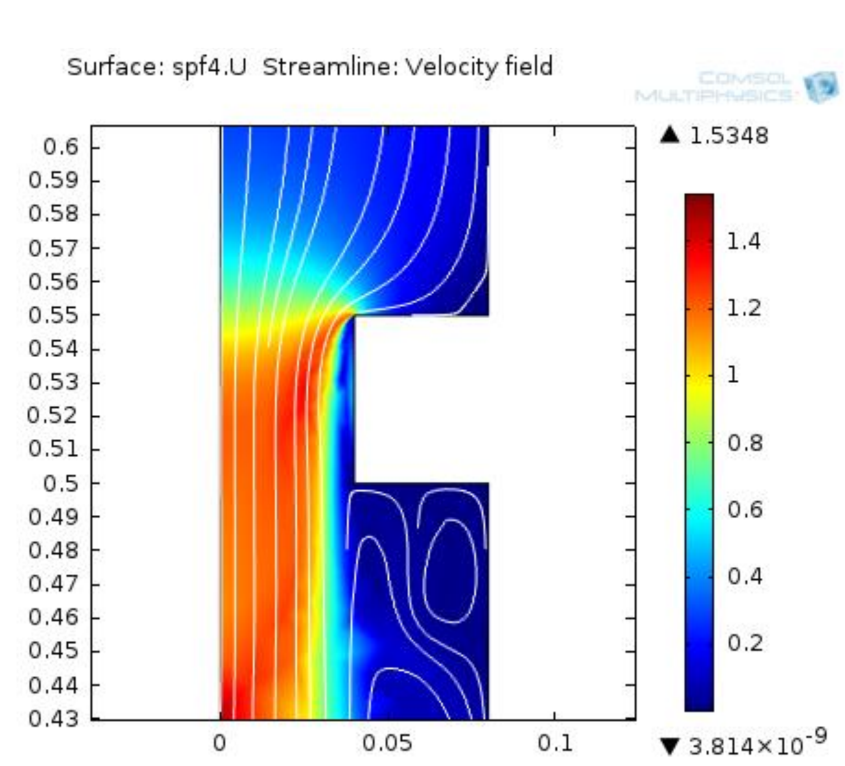

Figure 3. Flow details in the nozzle

Boundary conditions: at inlet: prescribed velocity turbulent intensity & length scale; at outlet: prescribed pressure; at symmetry axis: axial symmetry; at walls and bottom: no slip & wall functions

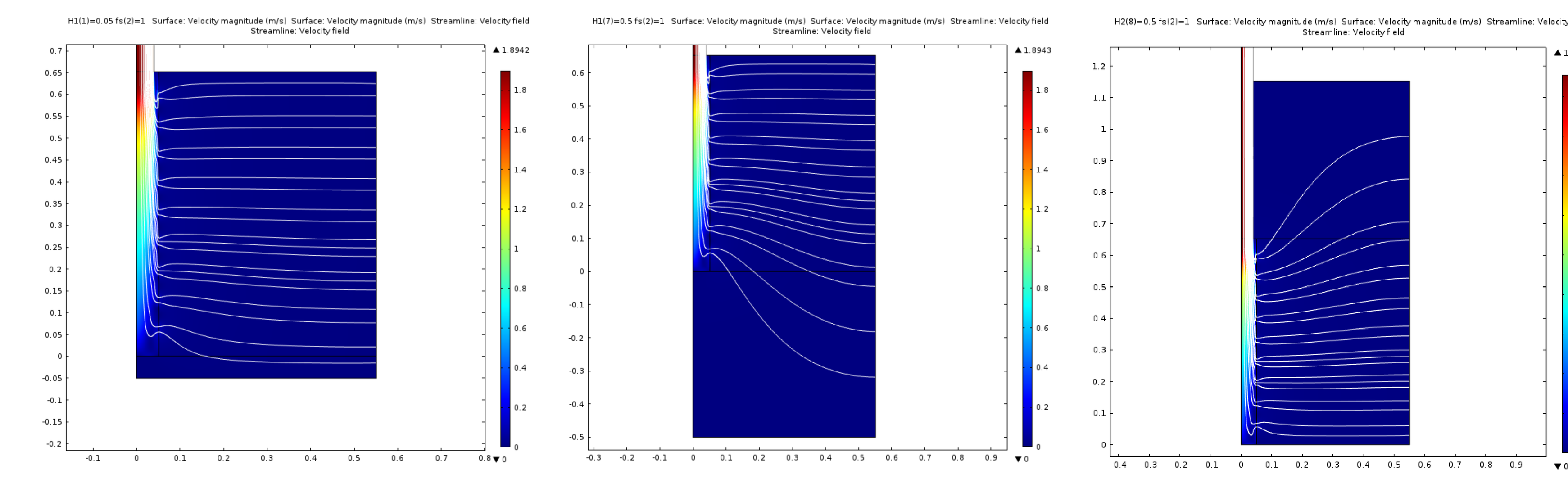

Figure 4. Flow pattern in bottom partition
hydraulic head colormap & streamlines; 3 scenarios

Results: Flow patterns are depicted in Figures 3 and 4. Using parametric runs, we examined the influence of the porous medium properties on the coupled flow regime. Also the position of the well screen in relation to the boundaries of the aquifer layer was studied (Figures 4 and 5).

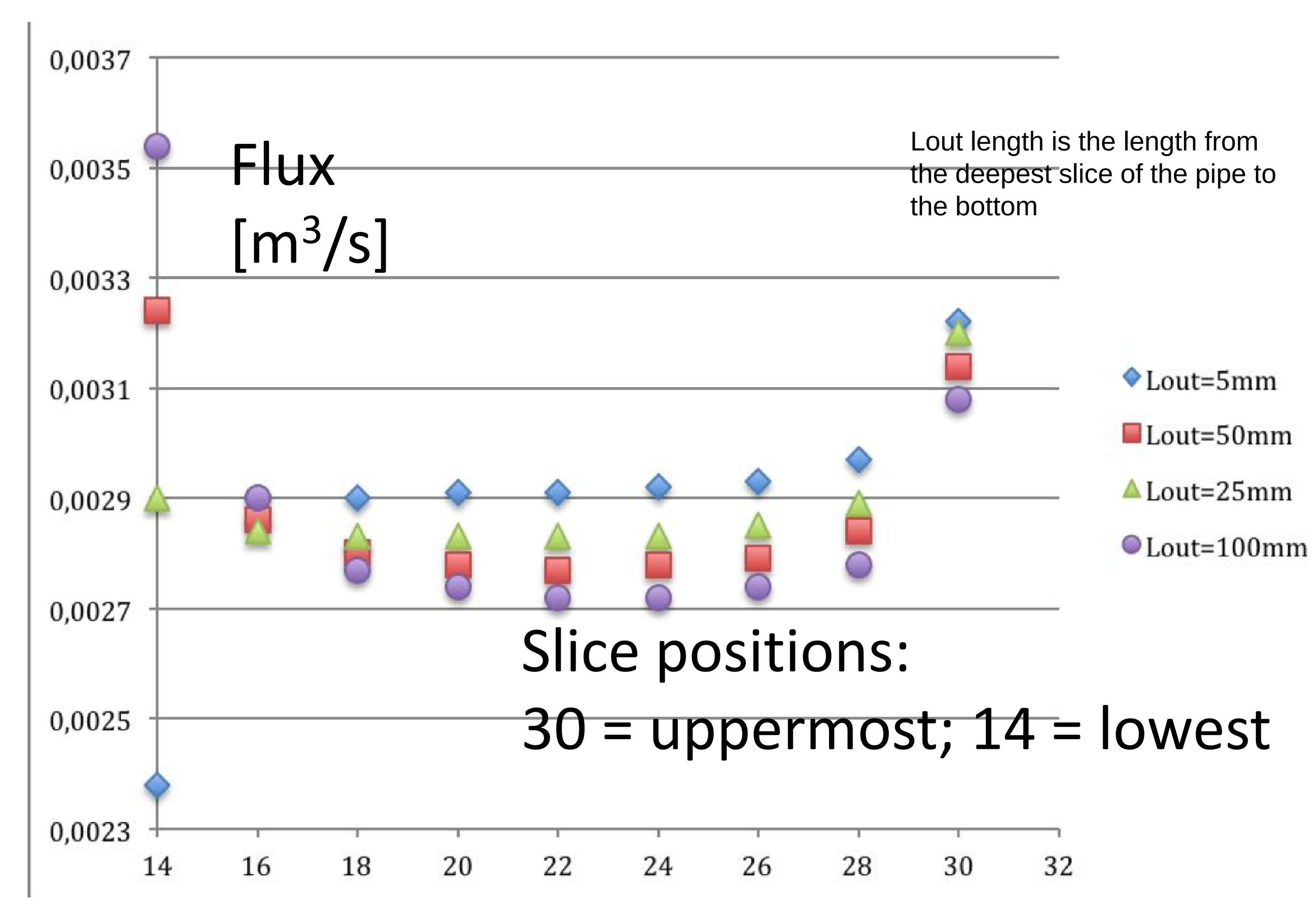

Figure 5. Filter slice characteristics

Conclusions:

❖Free laminar or turbulent flow in one sub-domain can be coupled with porous media flow in a connected sub-domain

❖Turbulence closure using k-ω reduces wall lift off effects better than k-ε closure

❖The outflux through different outlets of the screen depends very much on the pipe/nozzle design:

- the length of the pipe below the lowest outlet
- the position of the filter screen in relation to over- and underlying lower permeable layers

Acknowledgement:

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References:

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