Analysis of the surface/subsurface coupled evaporation for an energetic system

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Résumé

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1 - Introduction

Dealing with environmental flows may lead to major challenges in geosciences such as the coupling of porous medium and free flows to analyze the influence between them.

To simulate this configuration, one should develop a complete description of the flow in both domains in order to be accurate on the drying process quantification. As a first step, we focus on the modeling of all the phenomena involved in the porous medium. The numerical model is developed from an implicit pressure/ explicit saturation (1) open-source code based on the OpenFOAM software.

2-Mathematical and Numerical model

The multiphase flow in porous media is usually modeled using the generalized Darcy's law system of equations. When drying occurs, it is necessary to consider the evaporation and handle it correctly in the momentum equation by implementing a new term to the existing set of equations. Contrary to the initial model in which saturation is solved considering water in the wetting phase only the saturation equation is modified based on an existing Darcy generalized model (2). The component mass transfer in the non-wetting phase is considered, allowing water transfer from a phase to another following the variation of water mass fraction in the non-wetting phase and its diffusivity under those conditions.

To drive this mass transfer process and challenge our new set of equation, we use a boundary condition based on an evaporation rate (3) dependant on user determined parameters of a non-simulated free flow at the interface with porous medium.

3 - Results

To validate our new model, we must confront it to several experimental studies from the

*Intervenant

literature. The figure (1) shows the comparison between numerical results and an experimental work (4). On the left, we can see the evolution of the evaporation rate over time for different free flow average velocities and in the right sub-figure the associated total mass evaporated.

It can be seen that a good agreement between experimental and numerical studies is reached for 3 of the 4 velocities (3.5m/s, 2,5m/s and 1,5m/s). All numerical results show the same global tendancy of a constant evaporation rate for a few days followed by a sudden decrease and then another level seems to be reached. This evolution appears to be coherent with the observed results in the experimental study. The cumulative evaporation also shows good agreement between numerical and experimental. Nevertheless, for a small free flow velocity (u=0,75m/s), it seems that the initial evaporation rate is lower than expected seeing the experimental study, resulting in a total evaporation significantly smaller. This limitation needs to be furtherly studied.

Figure 1: Comparison of numerical and experiment evaporation results (see attached file "Comparaison_Shahraeeni_IMPESFoam.png")

4 - Conclusion

Based on several studies, we find a good agreement between our porous-only modeling approach and experimental litterature. The isothermal model is thus validated and adding the energy equation is the next step to have a full representation and understanding of the phenomena occuring in our case study.

References

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