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On modeling partially-saturated flow of a liquid in multilayered thin swelling porous media

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Understanding fluid flow and deformation processes in thin swelling porous media is critical for developing superior consumer absorbent hygiene products such as wipes, paper towels, feminine pads and diapers [1-4]. Fluid-flow models have proven very valuable for the development of these products and have led to the development of fundamental understandings in transport mechanisms, numerical simulation tools, computation infrastructure and lab methods for both characterizing absorbent materials as well as validation of flow and deformation models.

In this study we developed a quasi -2D averaged macroscopic mass balance model, based on the volume averaging approach [5-17], for modeling partially-saturated flow of a liquid in multilayered thin, absorbing swelling porous media. In order to describe the absorbency process in [18], fast and accurate simulations with this model are carried out to predict the time and spatial behavior of variables such as piezometric head, saturation, porosity, and layer thickness, and to understand the flow and storage of a liquid in conjunction with the layer deformation. This model enormously improved the computational speeds, allowing to develop a fast and reasonably accurate simulation of the unsaturated flow at lower cost. The numerical results of the simulations predicted well the flow fields of both liquid and solid phases and were in good agreement with the experimental and previous numerical results.

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