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Impregnation of liquids into a laminated porous material with a high permeability contrast

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Abstract

This paper sets the physical basis for an efficient method designed to fill low permeable porous materials with liquids. Fast filling of these materials is achieved if one sandwiches a slightly permeable sample between highly permeable layers. We derived a useful engineering formula for the front speed as a function of the layer permeability and thickness. An asymptotic analysis of the two-dimensional liquid flow with moving front is performed assuming that the covering layers are much thinner than the sample thickness. It is shown that the front forms sawteeth with the tooth apexes moving along the highly permeable layers. If the surface layers are made of the same material, two sawteeth are mirror symmetric with respect to the sample midplane. The angle which they form drastically depends on the ratio of layer-to-sample permeabilities and on the ratio of skin-to-core thicknesses. The theory presented in this paper can be used to optimize the processes of impregnation of nanostructured materials. © 2007 American Institute of Physics.

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