PORE-LEVEL MODELING OF ISOTHERMAL DRYING OF PORE NETWORKS. EVAPORATION AND VISCOUS FLOW

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***Abstract* -- Simulation results of drying of non-hygroscopic liquid-wet rigid porous media are presented. Two and three-dimensional pore networks represent pore spaces. Two kinds of mechanisms are considered: evaporation and hydraulic flow. The process is considered under isothermal condition. Under these conditions capillary forces are dominant over viscous forces; drying is thus considered as a modified form of invasion percolation. Liquid in pore corners allows for hydraulic connection throughout the network at all times. As drying progresses, liquid is replaced by vapor by two fundamental mechanisms: evaporation and pressure-gradient-driven liquid flow. Using Monte Carlo simulation, we find evaporation and drainage times; the shortest calculated indicates the controlling mechanism. Here we report distributions of liquid and vapor as drying time advances. Predictive drying curves and liquid distributions compare well with experimental results for hexane in transparent two-dimensional micromodels. Liquid permeability and vapor diffusivity are reported as functions of liquid saturation.**

***Keywords* -- pore-level drying, drying front, network modeling, Monte Carlo simulation.**

I. INTRODUCTION

A better understanding of drying is essential to delineate optimum processes. Drying is scientifically and technically important. Space limitations prevent us from a complete review of the subject. We limit attention to the main contributions in the area of pore-level modeling. Daian and Saliba (1991) and Nowicki *et al*. (1992) proposed the first network models to determine macroscopic transport parameters, namely relative permeability of liquid and effective diffusivity of vapor, and their dependency with liquid saturation, distribution of saturation and history of drying. Prat and coworkers, see for instance a recent review by Prat (2000), and Yortsos and coworkers, see for instance Tsimpanogiannis *et al*. (1999) and Yiotis *et al*. (2001), studied drying patterns and drying fronts both theoretically and experimentally. Visualization experiments of drying in two-dimensional transparent micromodels are central in identifying pore-level drying mechanisms. Among the first are those of Shaw (1986). Here we present a mechanistic pore-level model of drying incorporating viscous pressure-gradient-driven flow and evaporation in two and three-dimensional pore networks to determine pore-level distribution of gas and liquid, drying curves, permeability of liquid and diffusivity of vapor as function of liquid content. Predictive drying curves and liquid distributions are compared with experimental results for hexane in transparent two-dimensional micromodels.

II. NETWORK MODEL

Porous media are represented by rigid two-dimensional square and three-dimensional cubic networks of prismatic pore bodies connected by narrow pore throats of rectangular cross section circumscribing circles of given radii and depth. Figure 1 displays a typical portion of the pore network and corresponding parameters. Throat radii r_t, or equivalently throat section short-side half-lengths, are randomly assigned according to probability density functions $f(r_t)$. Pore throat depth h is constant. Pore-body-center to pore-body-center distance L is chosen constant. Pore throat length L_t is constant and equal to a fraction β of L. Pore body side half length L_b is constant and equal to $((1-\beta)L/2)$; body depth is also constant and equal to the throat depth. Fixing the factor β fixes the porosity of the network once $f(r_t)$ and L are given.

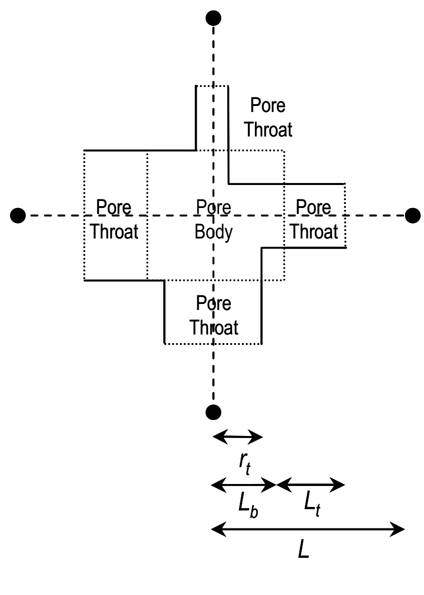

Figure 1. Pore network and parameters.