Comparison Between Flow Simulations and Flow Experiments in Porous Media

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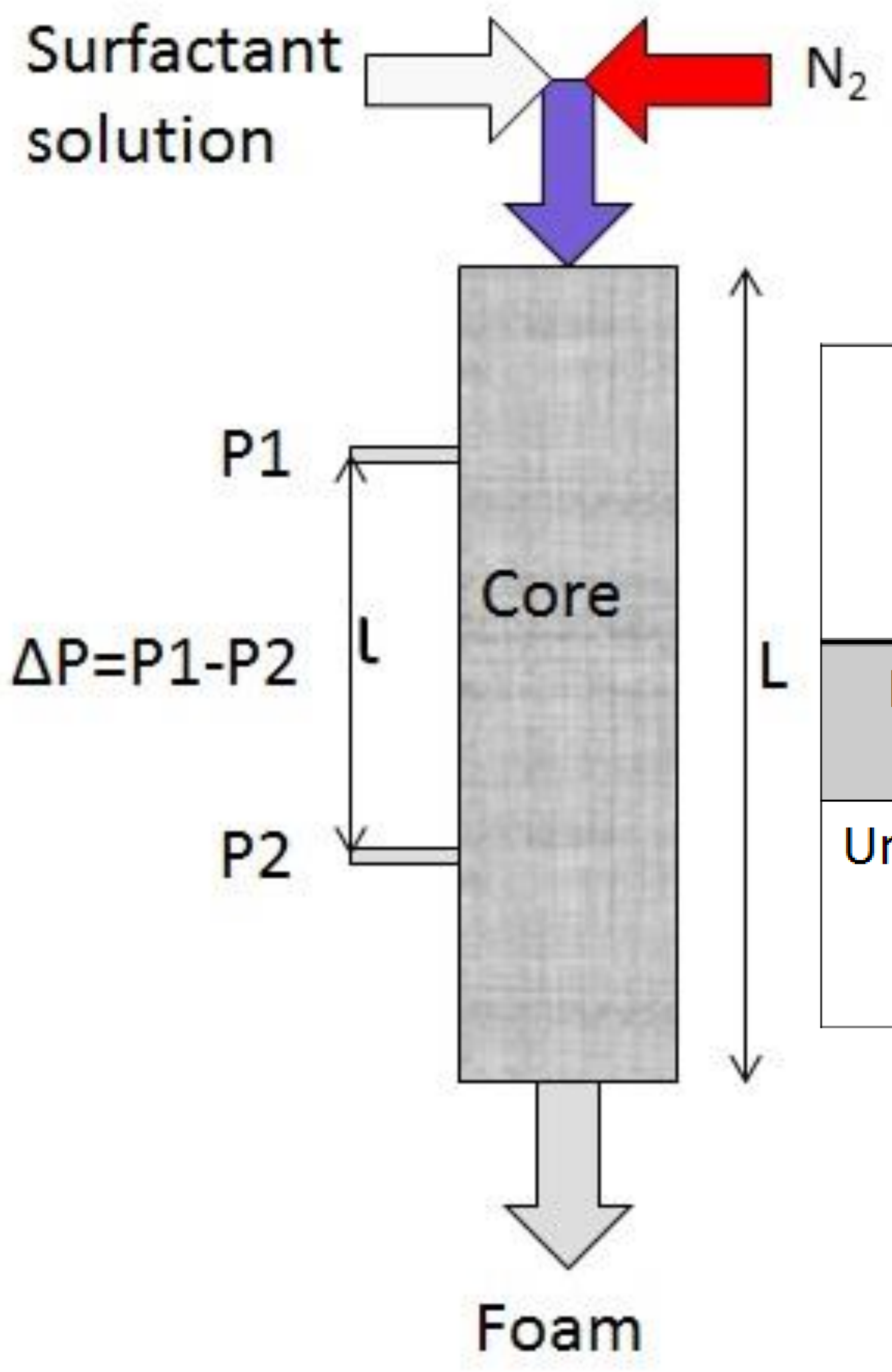
Introduction: Foam flow through porous media has been studied extensively. Our hypothesis is that it is possible to formulate a three equation model in terms of pressure, saturation and foam bubble density that can interpret the experimental results.



	Core length, L(cm)	Measure pt. ι (cm)
Bentheimer	17	9
Unconsolidated sand	15	6

Figure 1. Experimental set up for the foam flow

Computational Method: In order to interpret the experiment we simulated the foam propagation process with a 1D model along coordinate x. The model leads to three equations, i.e., the pressure equation(shown below), the water balance equation and the foam generation equation. A trial and error method was used to optimize the foam generation function to simulate the experimental pressure difference history profile. We use COMSOL to solve the equations after converting to weak form.

$$\varphi\left(c_w s+\frac{(1-s)}{p}\right)\partial_t p+\frac{kk_{rg}(s)}{\mu_f(n)}\left(\partial_x p-\rho(p)g\right)+$$

$$\frac{k_{rw}(s)}{\mu_w}\left(\partial_x p-\rho_w g\right)+\frac{kk_{rg}(s)/p}{\mu_f(n)}\left(\partial_x p-\rho(p)g\right)+$$

$$\frac{kk_{rw}(s)c_w}{\mu}\left(\partial_x p-\rho(p)g\right)\partial_x p$$

Results: Fig.2 and 3 show the bubble density and saturation profile in the direction of the sand pack from the start *(t=0)* of co-injection(Violet line) to steady state foam flow(red line). Figure 3 shows agreement between experimental and theoretical pressure drop.

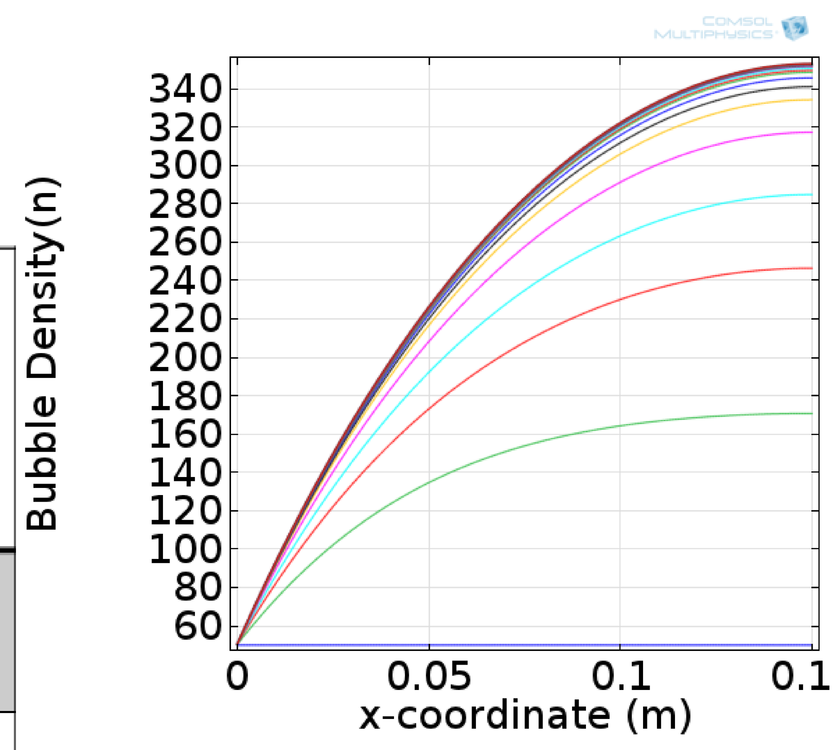


Figure 2. Bubble density

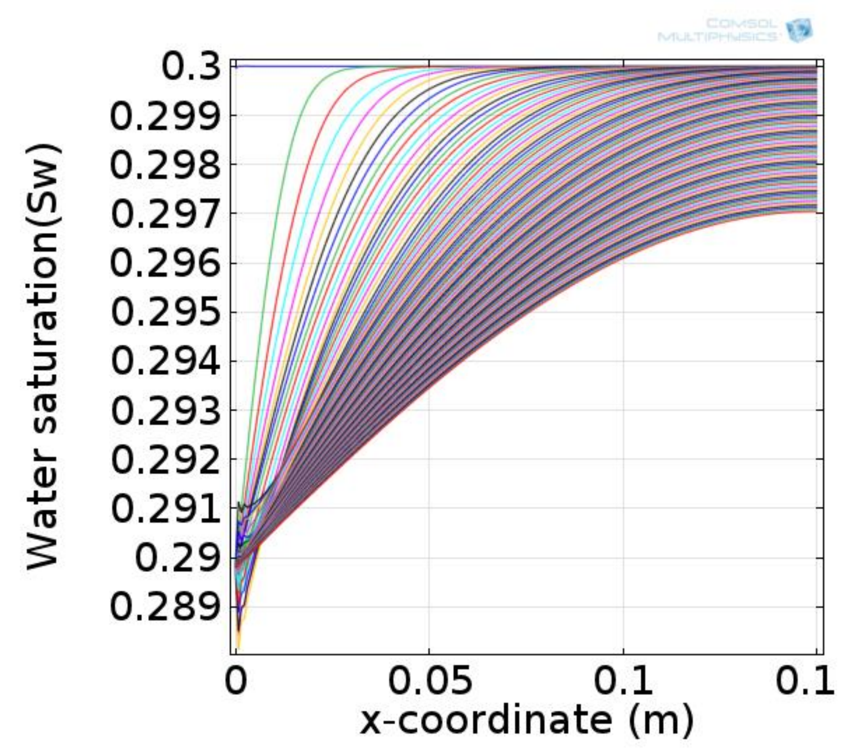


Figure 3. Saturation profile

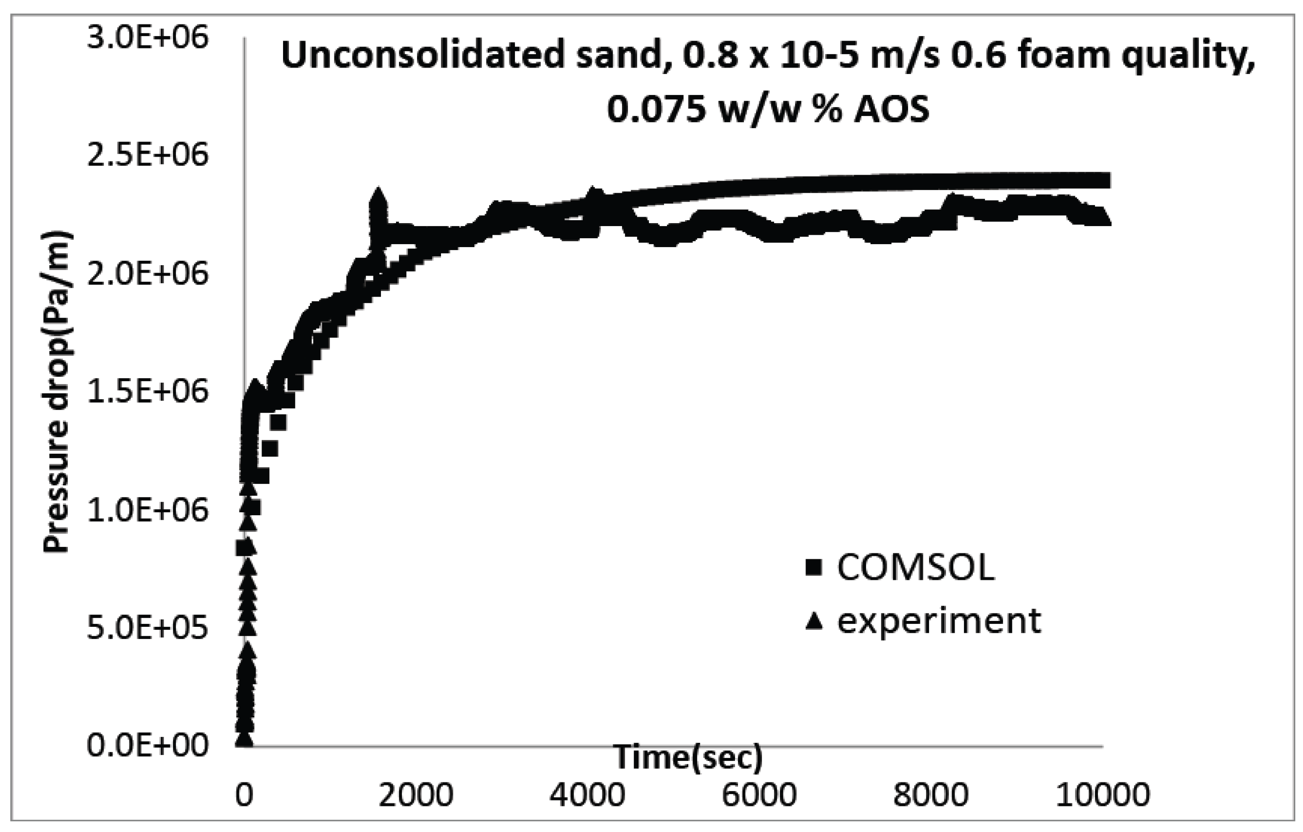


Figure 3. Pressure profiles during foam flow

Conclusions: COMSOL is able to reproduce some features of foam flow using the empirical data from the experiment in an unconsolidated coarse sand containing a surfactant solution.

Future work entails best-fit generating functions by comparison of experiments with different porous media (unconsolidated sand versus Bentheimer). It is aimed to determine whether a texture dependent- or a case dependent-generation function is needed to explain the foam flow.

References:

1. Simjoo M., Immiscible foam for Enhanced Oil Recovery, PhD Thesis, Delft University of Technology(2012).

2. Rossen, W. R., Ed. Foams in Enhanced Oil Recovery. Surfactant Science Series, New York (1995).

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