Foam Generation and Propagation in Porous Media

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ABSTRACT

Foam is a promising means of improving oil recovery from petroleum reservoirs, increasing the efficiency and safety of subsurface CO_2 sequestration, recovering non-aqueous wastes from aquifers. The ability of foam to propagate far from an injection well at modest pressure gradient is crucial to these applications. The issue of foam propagation is related to that of foam generation [1]. Foam creation in steady gas-liquid flow in porous media depends on exceeding a minimum pressure gradient, which triggers mobilization of an initial population of resident liquid films to multiply in the porespace. Models and experiments show that foam can exist at multiple steady states at the same injection conditions (Fig. 1). This implies that there is a minimum velocity or pressure gradient both for foam generation and foam stability. Recent modelling research [2] showed a surprising prediction: foam propagation fails at a velocity larger than that at which foam itself becomes unstable. In the model, this occurs when foam generation fails to keep up with foam destruction at the leading edge of the foam front.

We test and confirm this prediction of theory with experiments injecting surfactant solution and N_2 gas into a sandstone core of increasing diameter from inlet to outlet. We create foam in a narrow inlet section and test it's propagation at lower velocity in wider, downstream sections. Then, reducing the injection rate, we measure the minimum velocity for foam stability, working backwards from wider to narrower sections. As a result, we obtain multiple measurements of the minimum velocities and pressure gradients for foam generation, propagation, and stability in place. Implications of this behaviour for field application of foam are discussed.

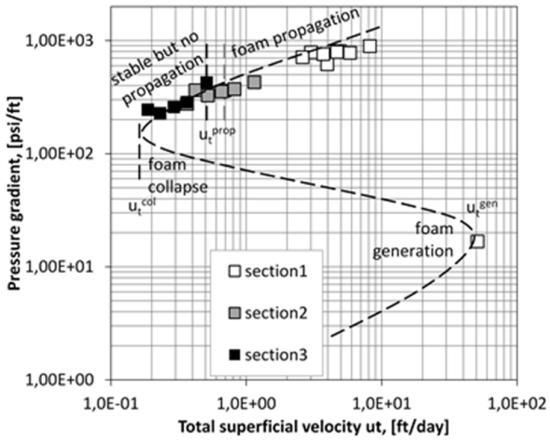

Figure 1: Pressure gradient as a function of superficial velocity measured in co-injection of surfactant solution and N_2 into sandstone core.

[1] Gauglitz, P.A., et al., *Chem. Eng. Sci*. **57**, 4037-4052 (2002).
[2] Ashoori, E., et al., *SPE Journal* **17**, 1231-45 (2012).
[3] Yu, G., et al., EAGE IOR Symposium, Pau, France , April 8-10, 2019.