Foam flow in porous media at the pore scale

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Foams are quite widely used for the stimulation of mature reservoirs as they allow a high viscosity fluid to be produced in-situ from comparatively low viscosity constituents. One of the restrictions on the use of foams for reservoir stimulation is our comparatively rudimentary ability to predict and control the behaviour of the foam phase compared to our ability to predict the behaviour of other phases within a reservoir. This is largely because the rheology of the foam within the porous media is very non-Newtonian and only weakly dependent on the rheology of the constituent fluids, while being strongly dependant on the bubble size and the pore geometry. The bubble size itself is controlled by the pores, as they are crucial to the creation and destruction of the films that separate the bubbles. This means that the rheological properties of the foam will evolve both spatially and temporally in a manner that is not easily captured in the traditional framework of rock dependent absolute permeability and saturation dependent relative permeability.

This study will use a range of experimental techniques to understand the behaviour of foam in porous media at different pore sizes and geometries. 3D printing will be used to manufacture a series of media with pore arrangements of increasing complexity, with macro-photography and high-speed photography used to obtain bubble coalescence and rheological data that allow the characterization of foam behaviour at the pore scale.

Furthermore, this project will extend previous work on pore scale modelling of the motion of films as they traverse a single pore of variable cross-section (i.e. Cox et al., 2004) into more complex geometries so that the effect of having multiple interlinked pores on the apparent rheology of the foam can be assessed numerically. In addition to the pore arrangements used for the experimental part of this work, more realistic pore networks will also be considered, which will be obtained from microCT imaging of the voids within actual reservoir rocks.

The ultimate outcome of this work will be an understanding of the pore scale foam dynamics that can be used to develop improved continuum scale models for foam flow for implementation within reservoir scale simulators.

Reference: Cox SJ, Neethling SJ, Rossen, WR, Schleifenbaum, W, Schmidt-Wellenburg,P and Cilliers, JJ, 2004. Colloids and Surfaces A, 245:1-3, pp 143-151

This project is available for students who apply for Imperial College scholarships or other international scholarship schemes. For more information please contact Pablo Brito-Parada (p.brito-parada@imperial.ac.uk) and Stephen Neethling (s.neethling@imperial.ac.uk)