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Flow of a two-dimensional aqueous foam in two parallel channels

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Flowing foams are used in many engineering and technical applications. A well-known application is oil recovery. Another one is the remediation of polluted soil: the foam is injected into the ground in order to mobilize chemical species that are initially present in the medium. Apart from potential interesting physico-chemical and biochemical properties, foams have pecular flow properties that might be used in order to reach regions of the medium that are normally the least permeable. We study here this physical aspect of the topic.

As a precursor to the study of foam flow through a complex porous material, we study the behaviour of an aqueous two-dimensional foam flowing through a medium consisting of two parallel channels with different widths, at fixed medium porosity, that is, at fixed total combined width of the two channels. The flow velocity, and hence flux, in each channel is measured by analyzing images of the flowing foam. The corresponding pressure drop along each channel is calculated based on theoretical arguments involving both (i) a dynamic pressure drop, which is controlled by bubble–wall friction, and (ii) possibly a capillary pressure drop over the bubble films that emerge at the channel outlet, the latter pressure drop being controlled by the radius of curvature of the bubble film.

The flow behaviour of the foam happens to not uniquely be determined by the channel width, as would be the case for a Newtonian fluid, but also to be highly dependent on the foam structure within the narrowest of the two channel, especially when a “bamboo” structure is obtained. Consequently, the flux in a channel is found to have a more complicated relation to the channel width than expected. We try to define a corresponding medium permeability and compare it to the permeability expected for the flow of a standard newtonian fluid in the same geometry.