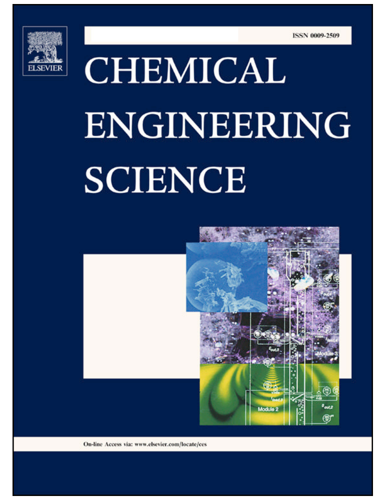
Accepted Manuscript



Interface tracking of an oil ganglion inside a cascade of pore bodies and pore throats: A quasistatic investigation

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PII: S0009-2509(18)30548-7
DOI: https://doi.org/10.1016/j.ces.2018.07.053
Reference: CES 14407

To appear in: *Chemical Engineering Science*

Received Date: 10 May 2018
Revised Date: 23 July 2018
Accepted Date: 24 July 2018

Please cite this article as: A. Salama, Interface tracking of an oil ganglion inside a cascade of pore bodies and pore throats: A quasistatic investigation, *Chemical Engineering Science* (2018), doi: https://doi.org/10.1016/j.ces.2018.07.053

Interface tracking of an oil ganglion inside a cascade of pore bodies and pore throats: A quasistatic investigation

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Abstract

The study of the permeation of oil droplets through a network of pore bodies and pore throats is complicated because of the need to track both the advancing and the receding interfaces and the possible branching of the oil ganglion. For the sake of simplicity and to gain understanding of the features associated with the motion of a droplet in a network, in this work, we eliminate the possibility of branching. In other words, we consider the case in which the oil droplet moves through a cascade of pore bodies and pore throats. In this case only two interfaces need to be tracked; namely the receding and the advancing interfaces. While it was possible to derive analytical expressions to determine the critical entry pressures when the oil droplet is still at the surface of the cascade, it remains challenging to find such analytical expressions when the oil droplet completely enters it. In this case both the advancing and the receding interfaces play a role. When the oil droplet completely enters the cascade, it becomes an oil ganglion, the movement of which is determined by the entry pressure. The entry pressure depends on the curvatures of both the leading and receding interfaces. This implies that the entry pressure is changing along the cascade. The largest values of the entry pressure, however, are those obtained when the leading interface is in a pore throat and the receding interface is in a pore body. In this work, we estimate the entry pressure in two situations; namely, when the leading interface is at the entrance of a pore throat and, likewise, when it is at the end. One can then infer how the entry pressure changes along the pore throat length. To determine the curvature of the receding interface, we use the fact that, for incompressible fluids (which is our case), the volume of the oil ganglion is conserved and that the interfaces assume the static contact angle at the contact with the wall. A nonlinear algebraic equation is developed, the solution of which provides the radius of curvature of the receding interface. Interesting results are obtained including the entry pressure values at different locations, the distribution of the oil ganglion along the cascade, and the radius of curvatures of the leading and the receding interfaces.

Keywords: Pore network models, Oily-water filtration, Ceramic membranes, Entry pressure

Introduction

Surface phenomena play crucial role in many engineering applications including pharmaceutical, food, petrochemical, and many other industries. Different materials that are immiscible with each other tend to form interfaces when they get mixed together. Such interfaces keep the identity of each phase and influence the behavior of the phases when they are stressed. In addition, they give rise to surface forces that influence the shape of the interface. Although surface forces are, generally, microscopic in nature, their effects combine such that a macroscopic, overall behavior appears. Such surface forces work to minimize the area of exposure of the phases in contact. Therefore, there is a direct relationship between surface forces and the curvature of the interface. A pressure term appears as a manifestation of the curvature of the interface such that