Résultats de l'article 1

Maxime Cochennec

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Outline

1. Introduction
2. Results

Flow regimes and instabilities in Hele-Shaw cell

- Flow regimes:
  - continuous stream
  - drop and/or ganglia flow

Break-up of the invading fluid by snap-off?

- Instabilities:
  - Saffman-Taylor
  - Rayleigh-Plateau (see (b) bellow from [1])

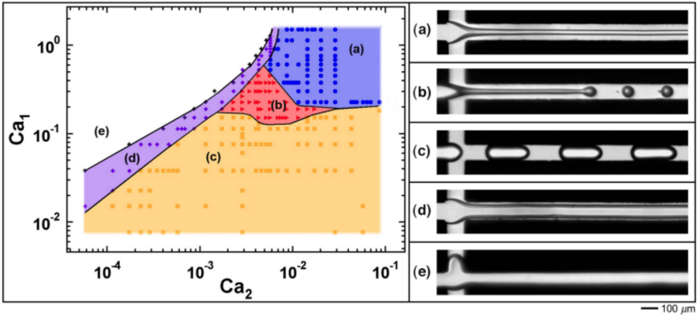


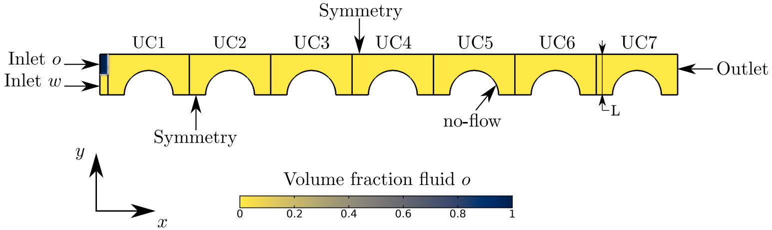
FIG. 1. (Color online) Typical capillary number-based flow map with flow patterns: (a) threading (●), (b) jetting (▶), (c) dripping (■), (d) tubing (♦), (e) viscous displacement (+). fluid pair: *G3B*.

Boundary conditions and simulation parameters

Boundary	u	p	ϕ
Outlet	-	0	$\mathbf{n} \cdot \nabla\phi = 0$
Inlet o	u_o	-	0
Inlet w	u_w	-	1

Parameters	Value
$Ca = \frac{U_t \mu_o}{\gamma}$	from 0.125 to 0.005
$M_w = \frac{\mu_w}{\mu_o}$	1
$f_f = \frac{u_w}{U_t}$	1/4
$h^* = h/L$	from 5 to 1/20

Table: Boundary conditions (left) and simulation parameters (right)



Equations

If $\nabla \epsilon_i \approx 0$, the momentum transport equations read

$$0 = -\varepsilon_w \nabla \langle p_w \rangle^w - \mu_w k^2 \langle \bar{\mathbf{u}}_w \rangle + \mathbf{d}_{wc} + \mathbf{d}_{wo}, \tag{1a}$$

$$0 = -\varepsilon_o \nabla \langle p_o \rangle^o - \mu_o k^2 \langle \bar{\mathbf{u}}_o \rangle + \mathbf{d}_{ow}. \tag{1b}$$

where, $\mathbf{d}_{ij}$ has dimensions $\mathrm{Pa.m}^{-1}$ i.e. drag forces per unit surface area (of unit-cell).

Drag definition

$\mathbf{d}_{ij} = \frac{1}{S} \int_{\Gamma_{ij}} \sigma_i \cdot \mathbf{n}_{ij} \, \mathrm{d}\Gamma,$

- σ_i is the stress-tensor for a Newtonian fluid i,
- S is the unit-cell's surface
- $\mathbf{n}_{ij}$ is the unit normal vector pointing toward the j-phase.

Drag

Drag of... upon...	Fluid o	Fluid w	
Plates	$-\mu_o \langle \bar{\mathbf{u}}_o \rangle \frac{12}{h^2}$	$-\mu_w \langle \bar{\mathbf{u}}_w \rangle \frac{12}{h^2}$	$\Sigma = \mathbf{d}_s$
Wedge	-	$\mathbf{d}_{wc}$	
Fluid o	-	$\mathbf{d}_{wo}$	$\Sigma = \mathbf{d}_f$
Fluid w	$\mathbf{d}_{ow}$	-	

Table: Summary of each drag force terms involved in the averaged momentum transport equations for two-phase flows in a Hele-Shaw cell.

Information

In the following we are interested in the x-component of the drag (i.e. component align with the main flow direction).

Results: flow regimes

Results: saturation

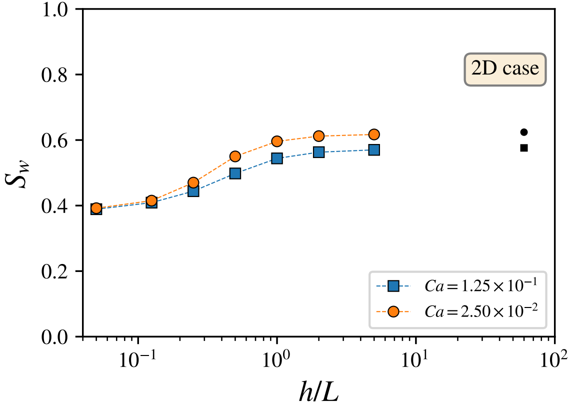


Figure: Saturation in wetting fluid as a function of the dimensionless gap between the plates.

Results: fluid-fluid interface

Results: solid-fluid drag force (1)

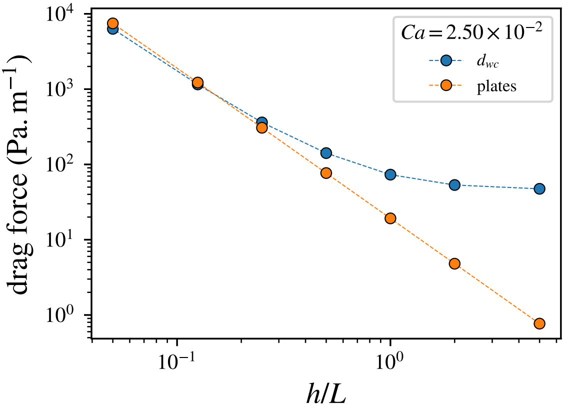


Figure: Comparison of the solid-fluid drag upon the wedge and upon the Hele-Shaw plates as a function of the dimensionless gap.

Results: solid-fluid drag force (2)

Drag upon the plates

1. constant inlet velocity whereas the gap between the plates is narrowing
2. drag : $-\mu_i \langle u_i \rangle \frac{12}{h^2}$
3. the drag upon the plates scales as h^{-2}

Drag upon the wedge

1. constant geometry
2. velocity gradient depends on the fluid-fluid interface position
3. pressure increases as the gap is narrowing

Results: fluid-fluid drag force (1)

Fluid-fluid drag

1. interface is changing (slightly)
2. pressure gradient increases as the gap is narrowing since the inlet velocity is constant

Results: fluid-fluid drag force (2)

Results: drag ratio

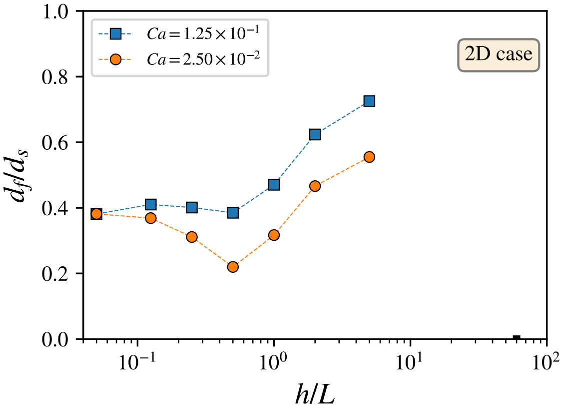


Figure: Ratio of fluid-fluid drag over solid-fluid drag as a function of the dimensionless gap between the plates.

Results: drag

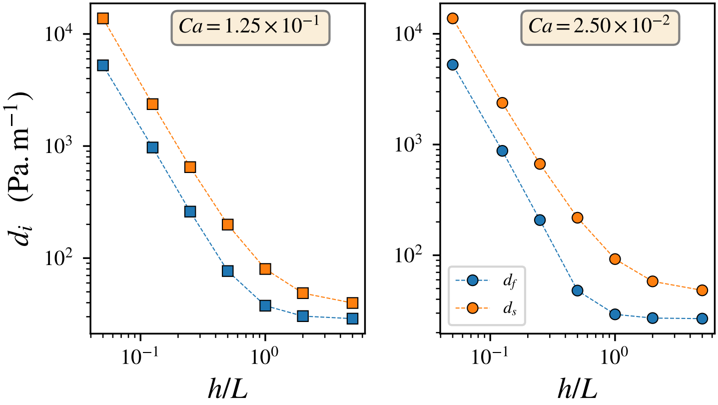


Figure: Comparison of fluid-fluid and solid-fluid drag force for differrent capillary numbers as a function of the dimensionless gap.

Results: Flat interface

What happens if the fluid-fluid interface is flat for $1 < h/L$?

1. we keep the drag upon the plates in the momentum transport equations
2. the contact angle is 0 and the pressure jump across the interface is only due to the $x - y$ curvature

Results: Dynamic film formation

By following [2], the thickness of the wetting fluid film scales, at leading order, as

$$\frac{h}{6} \tag{2}$$

for $Ca = 1.25 \times 10^{-1}$.

References

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Capillary threads and viscous droplets in square microchannels.
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C-W Park and GM Homsy.
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