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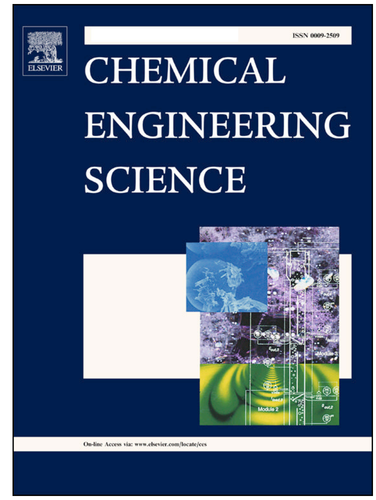

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Steady bilayer channel and free-surface isothermal film flow over topography

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Abstract

Two flow configurations, involving bilayers, are explored systematically: through an inclined channel comprised of two planar surfaces in parallel alignment and down an inclined plane. Both liquid layers are assumed to be perfectly immiscible and the lower rigid bounding surface contains locally defined steep-sided topographical features – either a step-up/-down or a trench. A common governing equation-set based on the long-wave approximation and depth-averaging is derived, embodying the more general case of a system of n-layers, and solved numerically.

Results for the particular case of flow in a vertically aligned channel are found to be indistinguishable from corresponding solutions in the literature; those for the case of a step-up and non-zero Reynolds number having not been reported hitherto. New to this, the case of flow in a inclined channel is investigated as is the situation when, in horizontal alignment, the channel's upper planar bounding surface moves with a constant speed inducing a shear flow.

Gravity-driven bilayer film flow reveals a number of interesting features dependent on the fluid properties, the Reynolds number and the ratio of the upper to lower liquid layer thickness, with parallels drawn to the practically relevant cascade/slide-coating mode of multi-layer thin-film deposition. In the limit when both layers have identical properties the corresponding equivalent single layer solution is recovered exactly.

Keywords: Bilayers, Interfacial and free-surface flow, Topography, Fluid mechanics, Mathematical modelling, Numerical solution

1. Introduction

Film flow involving one or more contiguously adjacent liquid layers, in the presence of surface topography, features in numerous processes of industrial relevance. These include, for example, the manufacture of micro-scale sensors and devices, [1], thin-film transistors, [2], OLED displays, [3], printed circuits, [4], and the formation of functional coatings comprised of different layers deposited simultaneously, using slot-die and slide/cascade arrangements, [5]. It has motivated numerous investigations, experimental and theoretical, over the past 30 years or so as to the affect of surface topography on thin film flow, directed primarily at understanding the gravity-driven flow of single layer films open to the atmosphere and about which much

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