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VISCOUS FLOW NEAR AN ANCHORED TRIPLE LINE

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ABSTRACT

The paper presents some simple solutions, in the immediate neighbourhood of an anchored triple line, for steady two-phase viscous flow of immiscible and incompressible fluids. The solution is a Stokes flow which is determined solely by the prescribed contact angle α of the interface between phases, the ratio μ, of their viscosities, and an arbitrary parameter β.

INTRODUCTION

The Lagrange stream function of the form $\phi \approx r f(\Theta)$ has the property that all velocity components are independent of r, and therefore is kinematically consistent with the no-slip condition on a plane boundary, which moves relative to the contact line. But this case does not yield a dynamically consistent solution. The possibility was first examined by Moffat (1964) for a single phase, and later by Huh & Scriven (1970) for the case of two viscous fluids. In both these papers the dynamical condition of the continuity of $\beta_i \beta_j \sigma_{ij}$ where σ_{ij} is a stress tensor, is not satisfied.

Criticism by these and later authors of such "solutions" have been of two main types; those which emphasize the infinite stresses and forces as $r \longrightarrow 0$, and hence their physical unreality, and those which pretend to call into question some of the accepted axioms of continuous flow. The first type of criticism seems to be valid for the case when a contact line moves relative to a smooth solid boundary, which was the context envisaged by Huh & Scriven (1970). However, since singular solutions generally have contributed much to an understanding of fluid mechanics, it seems worth while to enquire whether there are any flow phenomena to which solutions of the type sought by Huh & Scriven (1970) correspond. An appropriate example in the present context is the boundary value problem posed in Figure 1.

For $\beta>0$, it seems intuitively likely that an interface between two immiscible fluids can be "anchored" at the discontinuity in the kinematic boundary conditions, and the