

Corning Project Description

Two-layer Flow Behavior and Instability

I. Introduction, Significance and Objectives

Interfacial instability in two-layer fluid flow is a longstanding topic of interest due to its ubiquitous presence in nature and industry [1-6]. Some of the industrial examples include printing, coating, and laminations. At Corning, we support a variety of manufacturing processes in which the behavior and stability of multiple-layer flows are important. In addition to the typical issues of undesired structural defects or poor appearance resulting from the instabilities, we are also concerned in these products/processes with residual stresses, which can lead to short- or long-term performance degradation. Instabilities are also important in several new processes we are developing for new products, and so we expect the relevance of multiple-layer flows to continue and even increase at Corning. Therefore, we propose an investigation into various problems with this common theme of interfacial instability in multiple-fluid flow. The layers in the study will comprise Newtonian and non-Newtonian fluids.

II. Research Plan

We have the following roadmap for the project:

- a. Overview of two layer flows and their stability analysis.
- b. Extension of the confined geometry, i.e., extending to 2 or 3D to investigate the phenomenon for application to Corning's processes.
 - i. Development of linearized flow equations and their linear stability analysis
 - ii. Nonlinear stability analysis and numerical simulations
 - iii. Nonisothermal effects and presence of surfactant
- c. Consider two layer confined flow and also combination of flows containing free layers/free surfaces.
- d. Extension to multilayer flows.
- e. Instead of two layers, investigation of the effects of bubbles on flow behavior and instability.

III. Broader Impacts and Mentoring

This research project will have impact on Corning's multiple businesses in present and future projects. These problems are technically stimulating and challenging, and will add value to the researcher's career. Thus, this project provides a win-win opportunity for interested applicants.

We have led multiple projects and advised multiple undergraduate and graduate students in the past, as evident from our publication record. We have a combined track record of leading projects to success and eventually publication in high-quality peer-reviewed international journals.

IV. References

1. C.-S. Yin, Instability due to viscosity stratification, *J. Fluid. Mech.* (1983), vol. 27 part 2, pp. 337 – 352.
2. H. B. Square, On the stability for three-dimensional disturbances of viscous fluid flow between parallel walls, *Proc. Roy. Soc. A*, (1933), vol. 143, pp. 621.
3. A. L. Frankel and D. Halpern, Stokes-flow instability due to interfacial surfactant, *Phys. Fluid*, (2002), vol. 14, no. 7. pp. L45.
4. A. P. Hooper and W. G. C. Boyd, Shear-flow instability at the interface between two viscous fluids, *J. Fluid. Mech.* (1983), vol. 128, pp. 507-528.
5. J. Nam, Instabilities in two-layers slot coatings, IPRIME Annual Meeting, University of Minnesota, Minneapolis (2008).
6. J. Eggers and E. Villermaux, Physics of liquid jets, *Rep. Prog. Phys.* (2008), vol. 71, 036601.

V. Background Required

PhD in Applied Mathematics, Chemical Engineering, Mechanical Engineering

Please contact us for further clarification.

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