

THE DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING
STANFORD S. AND BEVERLY P. PENNER
DISTINGUISHED LECTURES



Surprising responses in flows in common geometries: (i) Surface-attached bacteria, biofilms and flow and (ii) Trapping of bubbles in stagnation point flows

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ABSTRACT

In this talk I describe two distinct problems that we have studied where seemingly modest variations in an elementary channel flow produce new effects. First, we investigate some influences of fluid motion on surface-attached bacteria and biofilms. In particular, we identify (a) upstream migration of surface-attached bacteria in a flow and (b) the formation of biofilm streamers, which are filaments of biofilm extended along the central region of a channel flow; these filaments are capable of causing catastrophic disruption and clogging of industrial, environmental and medical flow systems. Second we consider flow in a T-junction, which is perhaps the most common element in many piping systems. The flows are laminar but have high Reynolds numbers, typically $Re=100-1000$. It seems obvious that any particles in the fluid that enter the T-junction will leave following the one of the two main flow channels. Nevertheless, we report experiments that document that bubbles and other low density objects can be trapped at the bifurcation. The trapping leads to the steady accumulation of bubbles that can form stable chain-like aggregates in the presence, for example, of surfactants, or give rise to growth due to coalescence. Our three-dimensional numerical simulations rationalize the mechanism behind this phenomenon, which we argue is a consequence of vortex breakdown.

BIO

Professor Howard A. Stone received the Bachelor of Science degree in Chemical Engineering from the University of California at Davis in 1982 and the PhD in Chemical Engineering from Caltech in 1988. Following a postdoctoral year in the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, in 1989 Howard joined the faculty of the (now) School of Engineering and Applied Sciences at Harvard University, where he eventually became the Vicky Joseph Professor of Engineering and Applied Mathematics. In 1994 he received both the Joseph R. Levenson Memorial Award and the Phi Beta Kappa teaching Prize, which are the only two teaching awards given to faculty in Harvard College. In 2000 he was named a Harvard College Professor for his contributions to undergraduate education. In July 2009 Howard moved to Princeton University where he is Donald R. Dixon '69 and Elizabeth W. Dixon Professor in Mechanical and Aerospace Engineering.

Professor Stone's research interests are in fluid dynamics, especially as they arise in research and applications at the interface of engineering, chemistry, physics, and biology. In particular, he developed original research directions in microfluidics including studies and applications involving bubbles and droplets, red blood cells, bacteria, chemical kinetics, etc. He received the NSF Presidential Young Investigator Award, is a Fellow of the American Physical Society (APS), and is past Chair of the Division of Fluid Dynamics of the APS. For ten years he served as an Associate Editor for the Journal of Fluid Mechanics, and is currently on the editorial or advisory boards of Physical Review Fluids, Philosophical Transactions of the Royal Society, and Soft Matter, and is co-editor of the Soft Matter Book Series. He is the first recipient of the G.K. Batchelor Prize in Fluid Dynamics, which was awarded in August 2008. He was elected to the National Academy of Engineering in 2009, the American Academy of Arts and Sciences in 2011 and the National Academy of Sciences in 2014.