Indian Institute of Technology Kanpur

C. N. R. Rao Lecture Series

6 PM, Thursday, 25th February 2010, Venue: L-1, LHC

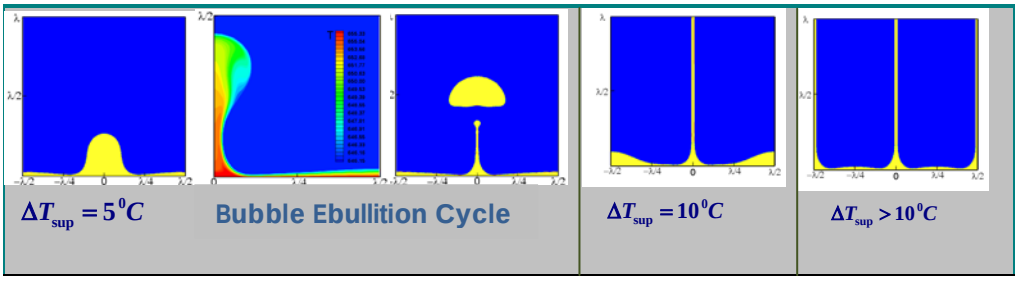
Professor Gautam Biswas, Director,
Central Mechanical Engineering Research Institute (Durgapur)

Understanding Vapor and Air Bubbles

The lecture discusses about a variety of free surface flows. The first one is the study of film boiling and bubble formation in water and R 134a on a horizontal heated surface. Thermal energy from the heated surface is absorbed by the liquid for phase change and the vapor film grows. Instability at the vapor-liquid interface leads to bubble formation. With further heat addition the vapor-bubble grows and consequently detaches from the vapor film under capillary forces and is buoyed away. Experimental investigations as well as many theoretical analyses depict the spacing between the nodes to be the Taylor's most dangerous wavelength of instability governed by the Taylor-Helmholtz instability. Our analysis reveals that the spacing between the nodes can also be dictated by the wavelength governed by Rayleigh-Taylor instability. Furthermore we perform CLSVOF (Coupled Level Set and Volume of Fluid) algorithm based numerical simulations in a large domain and show that although at higher superheats wavelength is independent of the wall-superheat, for lower superheats (where inertial forces are not dominant), wavelength decreases. Choosing a smaller domain we perform simulations to capture periodic cycles of bubble release from the nodes and antinodes. For higher superheats we observe bifurcation from the regular periodic bubble formation to formation of stable vapor columns.

Next, we study the problem of dynamic air bubble formation from a submerged orifice in quiescent liquid, under constant inflow condition, at normal and reduced gravity levels. For the described study, we mainly focus on low and medium air flow rates for the bubble formation at the orifice. The employed gravity levels are normal and significantly reduced gravity. The attention has been on the influence of buoyancy on bubble shape. The study includes the bubble volume, formation frequency, pinch-off rate, detached bubble diameter and the bubble growth history for different air flow rates. Even for the static contact angle, it is observed that at low gravity levels the bubble base spreads along the surface of the orifice plate away from the orifice rim during the expansion stage, and during the detachment stage the bubble base again comes back to the orifice rim. As the air flow rate is increased under normal and reduced gravity conditions, coalescence between the rising bubbles or between the detached bubble and the forming bubble at the orifice is observed.

We also analyze the problem of dynamic bubble formation from a submerged orifice in an immiscible Newtonian liquid under the condition of constant gas inflow. We consider two cases for the surrounding liquid, namely, liquid in quiescent condition and liquid as the co-flowing stream with the gas. The full cycle, from formation to detachment of the bubbles and the corresponding bubble dynamics, is simulated numerically. In this study, we primarily focus on dynamic regime of bubble formation, governed by the interplay of inertial, viscous, surface tension and buoyancy forces. Furthermore we pay attention on single periodic bubble (period- 1 bubbling regime) formation and the dynamics associated with it. We identify the situations that avoid the coalescence of bubbles (period- 2 bubbling regime). The influences of the liquid to gas mean velocity ratio, the Bond number and the Capillary number on the bubble growth, bubble break-up, bubble rising, interface shape, bubble volume, bubble formation frequency, bubble necking and pinch-off process in a quiescent and co-flowing ambient liquid are evaluated.



Previous Speakers:

Year	Name	Title
2009	V. Chandrasekhar	Single-Molecule Magnets
2008	Manindra Agrawal	The P<>NP Problem
2007	R.C. Budhani	Low-Dimensional Superconducting and Magnetic Material of Proven Technology Relevance
2006	Kalyanmoy Deb	Evolution Optimization for problem Solving and Knowledge Discovery
2004	Ashutosh Sharma	Of Small Things and other Stories

About the speaker

Gautam Biswas was born on May 23, 1956. He completed his PhD from IIT Kharagpur in the year 1985. He became a fellow of the Alexander von Humboldt Foundation in Germany. Dr. Biswas became a Professor in the Department of Mechanical Engineering at IIT Kanpur in 1995.

Prof. Biswas's research interests are in the areas of Computational fluid dynamics, Convective heat transfer, Turbulence, Boiling and free surface flows, Heat transfer augmentation, and Turbo machinery. He is also a former JSPS invited fellow in Japan.

Prof. Biswas has published over 84 research papers in the peer-reviewed SCI journals. He has completed guidance of eleven PhD theses and four are under progress. He has authored/ coauthored 8 books.

Prof. Biswas is a Fellow of the the National Academy of Engineering. He is a Fellow of Indian Academy of Sciences (Bangalore), American Society of Mechanical Engineers and Institution of Engineers. He is a Fellow of the National Academy of Sciences, India. In 2009, he became Director of the Central Mechanical Engineering Research Institute (CMERI) Durgapur. He was the occupant of Gurmukh and Veena Mehta Chair of Mechanical Engineering at IIT Kanpur before joining CMERI on deputation.

Contact: Dean, Research & Development