MHRD Scheme on Global Initiative on Academic Network (GIAN)

Physical Modelling of Multiphase Processes in Mineral and Chemical Processing

1.0 Overview

Many industrial processes involve interaction between gas, liquid and solid phases; and in today's world of global competitiveness and environmental awareness it's important that those interactions are performed as efficiently and with the least amount of energy and resource consumption as possible. The design and operation of processes that meet these requirements requires a good working knowledge of the underlying phenomena of heat, mass and momentum transfer that govern the behavior of multiphase flows. The size and dispersion of bubbles, droplets and particles is also very important and is closely associated with how and where the energy source is introduced into the system—where too much or too little or at the wrong location can have major detrimental effect in both product quality and operating costs.

India is a leader in domestic industrial manufacturing and provision of skilled engineers to the rest of the world. This reputation has been created by a strong engineering educational program focusing on mathematics and sciences. Specialization in a broad range of engineering fields is also developing; and this course is aimed at providing unique insight into the underlying principles of multiphase processes. It includes both (simple) theory and application to real work examples in the fields of mineral and chemical processing; and at the conclusion will provide the tools and knowledge needed to make informed choices that maximizes beneficial output in terms of energy usage, outputs and resource usage.

2.0 Objectives

The primary objectives of the course are as follows:

i) Introducing the basic principles underlying the behavior of multiphase systems commonly found in industrial processes,
ii) Building in confidence and capability amongst the participants in the application of the concepts that underlie the motion, energy usage and stability of multiphase processes as a function of their physical geometry and operating conditions,
iii) Providing exposure to practical problems and their solutions, through problems that reflect real challenges in the workplace,
iv) Enhancing the capability of the participants to apply basic principles of momentum and efficient energy utilization when designing and operating multiphase systems.

3.0 Teaching Faculty with allotment of Lectures and Tutorials

1. **Prof. Geoffrey Evans (GE) : 10 hrs lectures and 5 hrs tutorials**
2. **Dr. Raghvendra Gupta (RG) : 3 hrs lectures**

4.0 Course details

4.1 Tentative Duration: October 23 – October 27, 2017 (5 days) : 13 hrs lectures and 5 hrs Tutorials

4.2 Tentative Lecture Schedule

Day1

Lecture 1: 1 hr: GE

Introduction to multiphase processes, flow characterisation, flow regimes, flow parameters, dryness, volume fraction

Lecture 2: 1 hr: GE

Two phase flow models, homogeneous equilibrium model, volume fraction, pressure drop, two phase flow multipliers, Ergun equation

Tutorial 1: 1 hr: GE

Problem solving session with examples: two phase flow quality, pressure drop, flow regime determination

Day 2
Lecture 3: 1 hr: GE
One dimensional drift flux analysis, cocurrent/countercurrent flow, dispersed phase volume fraction, instability of flows
Lecture 4: 1 hrs: GE
Density-driven flows, momentum and energy balances, phase transport, air-lift pumps
Lecture 5: 1 hrs: RG
Introduction to approaches to model multiphase flows, Interface capturing techniques- volume of fluid (VOF) and level-set
Tutorial 2: 1 hrs: GE
Problem solving session with examples: Drift-flux analysis, gas-liquid flow, solids transport

Day 3
Lecture 6: 1 hr: GE
Introduction to mineral processing, flotation, bubble-particle interaction, product recovery, particle detachment
Lecture 7: 1 hr: GE
Mixing and gas dispersion in mechanically agitated vessels, gas dispersion, power consumption, solids suspension, bubble breakup
Lecture 8: 1 hr: RG
Euler-Euler and Euler-Lagrangian techniques to model multiphase flows
Tutorial 3: 1 hr: GE
Problem solving session with examples: design of mineral flotation cells for a given feed type and desired recovery

Day 4
Lecture 9: 1 hr: GE
Bubble columns, energy dissipation, gas injection, gas volume fraction, bubble breakup, homogeneous and heterogeneous regimes
Lecture 10: 1 hr: GE
Fluidised beds volume fraction of dispersed and continuous phases, pressure drop, minimium fluidization velocity, energy dissipation
Lecture 11: 1 hr: RG
Case Studies: CFD modelling of multiphase flows in mineral and process industries
Tutorial 4: 1 hr: GE
Problem solving session with examples: Design of bubble columns and fluidised beds with indutrial application, e.g. mineral flotation

Day 5
Lecture 12: 1 hr: GE
Aeration principles applied to wastewater treatement, mass transfer, bubble dynamics, oxygen transfer efficiency
Lecture 13: 1 hr: GE
Aeration requirements for biological systems, energy analysis, pressure drop, network of pipes analysis
Tutorial 5: 1 hr: GE
Problem solving session with examples: Design of simple aeration system for industrial wastewater treatment plant

Date of Examination: October 28, 2017

5.0 Who can attend?

- Executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories.
- Student students at all levels (BTech/MSc/MTech/PhD) or Faculty from reputed academic institutions and technical institutions.

6.0 Detailed CV of Experts

6.1 CV of Prof. Geoffrey Evans

Annexure 1

6.2 CV of Dr. Raghvendra Gupta

Annexure 2

7.0 Proposed Budget

Sl No	Description of budgetary head	Amount (Rs.)
1	International Expert travel expenses	1,50,000
2	Honorarium to Expert (US$300×10 + US$250×5 = US$4250)*68	2,89,000
3	Lecture notes/video-learning material preparation	50,000
4	Video recording expenses	50,000
5	Contingency & Miscellaneous	50,000
	GRAND TOTAL	**5,89,000**

Course Coordinator

Dr. Raghvendra Gupta
Assistant Professor,
Department of Chemical Engineering,
IIT Guwahati

Prof. Sunil Khijwania
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Formal Educational Qualifications

1982	B Eng (Chem), The University of Newcastle, First Class Honours.
1990	PhD, A Study of a Plunging Jet Bubble Column. The University of Newcastle, Australia.

Employment/Positions Held

2014–	Conjoint Professor, Beijing University of Chemical Technology
2014–	Visiting Professor, China University of Mining Technology, Xuzhou.
2009	"Professor B.D. Tilak Distinguished Lectureship", Mumbai University Institute of Chemical Technology, India
2003–	Professor in Department of Chemical Engineering, The University of Newcastle.
1999–2002	Associate Professor in Department of Chemical Engineering, The University of Newcastle.
1999–2001	Head of Department of Chemical Engineering, The University of Newcastle.
1995–1998	Senior Lecturer in Department of Chemical Engineering, The University of Newcastle.
1985–1994	Lecturer in Department of Chemical Engineering, The University of Newcastle.
1989–1991	Research Associate in Department of Chemical Engineering, University of Cambridge, England.
1984–1985	Research Officer with Australian Mineral Industry Research Association.
1983–1984	Analyst with ESSO Australia Limited, Sydney, Australia.

Memberships of Professional Bodies

2008–	Member, Particle Technology Society, Engineers Australia
2005–	Fellow, Institution of Engineers, Australia.
2004–	Fellow, Institution of Chemical Engineers (London).
1985–2004	Member, Institution of Chemical Engineers (London).
1992–2004	Member, Institution of Engineers, Australia.
1998–2001	Member, International Ozone Association.
1995–1999	Member, American Institute of Chemical Engineers.
1994–1996	Member, Australasian Fluid and Thermal Engineering Society.
1988–1991	Member, Institution of Chemical Engineers, Mixing Group, United Kingdom.

Prizes and Awards

1. Outstanding Paper Award, Best Paper in Multiphase Flows, "Interaction of a Spherical Particle with a Confined Liquid Film", S. Mitra, E. Doroodchi, **G.M. Evans**, V. Pareek, J.B. Joshi, Proceedings of the 10th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics, 14-16 July, 2014, Orlando, Florida.
2. John A Brodie Medal, of the Institution of Engineers, Australia, 2004. For the best paper presented at the annual meeting of chemical engineers in Australia, Chemeca '04, in honour of Mr John Brodie, the eminent industrial chemical engineer.
3. CSIRO External Medal for Research Achievement, 1990. Awarded by CSIRO annually to an individual or research team for significant research achievement that, amongst other factors, makes "substantial contribution to Australia's industrial development and achieves national objectives". Awarded to the applicant as a member of the "Jameson flotation cell" development team.

Professor Evans' principal area of expertise lies in the areas of particle technology, multiphase processes, mass transfer and interfacial phenomena. Much of his research involves free surface phenomena and phase interaction between bubbles, particles and the liquid phase. These broad areas have included: bubble formation and growth, bubble nucleation, bubble breakup and coalescence, two and three phase flow, mixing and agitation, emulsions, and plunging and submerged jets. More recently, his research has included surface forces, particle-particle and bubble-particle interactions, as applied to a number of particle technology applications, particularly applied to fluidised beds and micro-systems. In the past 10 years he has published over 150 papers in scientific journals and conference proceedings.

The impact of this work can be attested by:

- Since 2010, Receiving over 1380 citations (Scopus) at h-index of 19. https://scholar.google.com.au/citations?user=Mm5LHzoAAAAJ&hl=en
- Being awarded the John A Brodie Medal, of the Institution of Engineers, Australia, 2004, for the best paper presented at the annual meeting of chemical engineers in Australia, Chemeca.
- Being awarded the Padmashri Dr G P Kane Chemcon Distinguished Speaker Award (2015).
- Receiving the "Professor B.D. Tilak Distinguished Lectureship" (2008-2009), Mumbai University Institute of Chemical Technology.
- Invitations to present Keynote Lectures at International conferences: Indian Chemical Engineering Congress, Chandigarh, 1999; International Symposium on Mixing in Industrial Processes, Niagara Falls, 2008; Fifth International Conference of Applied Mathematics and Computing, Plovdiv, 2008; 5th Asian Conference on Mixing, 2013; World Congress on Chemical Engineering, Montreal, 2009; 7th World Congress of Particle Technology, Beijing, 2014; Chemeca, Perth, 2014; 8th International Conference of Mixing in the Process Industries, Melbourne, 2014.
- Invitations to speak at industry and academic symposiums/workshops: CSIRO, Strategic Directions Workshop, Melbourne, 2000; Mineral Processing Symposium, Brisbane, 2007; Coal Processing Symposium, Brisbane, 2008; Chemical Engineering Future Directions Workshop, Mumbai, 2009.
- Invitations to present at other Institutions/Government Organisations: National Institute for Resources and Environment, Japan; Japanese Government Office of NEDO; Shizuoka University, Japan; Osaka University, Japan; The University of Surrey; Beijing University of Chemical Technology; The University of New South Wales; University Institute of Chemical Technology, Mumbai; Indian Institute of Technology, Delhi; University of CapeTown; Washington State University.

Professor Evans's ongoing impact in the field of the hydrodynamics of multiphase systems has led to significant contribution into research assessment and organisation, through:

- Appointment to the ARC College of Experts for the period 2013-2015. He was previously a member for the Engineering and Environmental Sciences panel from 2005-07. Previously, Professor Evans was an (OZ)READER for the period 2001-2004, and before that an (INT)READER for a number of years. In addition to the ARC, he has also been invited to review research submissions for (1) Research Council for Natural Sciences and Engineering of the Academy of Finland, (2) Research Council of Serbia, (3) Georgian Science Foundation, (4) National Fund for Scientific and Technological Development of Chile, and (5) the National Research Foundation of South Africa. He has also reviewed submissions for the Internationals Science Linkages, French-Australian Science Linkages, and Cooperative Research Centres programs:
- Reviewing for at least 25 journals and numerous conferences, providing critical judgement of research outcomes which encompass a broad spectrum of engineering and science:
- Examination of PhD thesis from Universities across Australia and overseas:
- Member, Editorial Boards for: Journal European Mineral Processing and Environmental Protection (2001-07); Journal Chemical Engineering and Processing, Elsevier (2007-current); Advanced Powder Technology Journal, Elsevier (2008-current). Institution of Chemical Engineers Research and Development Journal (2012-present).
- Guest Editor for: Chemical Engineering Science Journal (2002); Experimental Thermal Fluid Science Journal (2004); Asia-Pacific Journal of Chemical Engineering (2009); Advanced Powder Technology (2014).
- Appointment as Conference Chairman, 5th Int. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Eng, Australia, 2001.
- Member, International Conference Scientific/Organising Committees: Involvement in Major National and International Conferences: 6th World Congress of Chemical Engineering, Melbourne, 2001; 9th

Asian Pacific Confederation of Chemical Engineering Conference, Christchurch, 2002; 1st Conference on Process Innovation and Process Intensification, Edinburgh, 2002; 6th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, Vancouver, 2003; 16th International Congress of Chemical and Process Engineering CHISA, Prague, 2004, 7th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, Strasbourg, 2005; Fluid Mixing VIII Conference, London, 2006; 2nd Conference on Process Innovation and Process Intensification, ChristChurch, New Zealand, 2006; 8th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, New Delhi, 2007; International Conference on Water and Wastewater Treatment, Bangladesh, 2007; 13th European Conference on Mixing, London, 2009; Conference on Mixing in Industrial Processes, Montreal, 2009; International Conference on Particle Image Velocimetry, Melbourne, 2009; Particulate Processes in the Pharmaceutical Industries III, Gold Coast, 2010; 10th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, Portugal, 2010. 11th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, Seoul, 2013. 12th Intern. Conf. on Gas-Liquid and Gas-Liquid Solid Reactor Engineering, New York, 2015.

- Session Chairman at numerous national and international conferences.

Professor Evans was elected as a Fellow of the Institution of Chemical Engineers (London) in 2004; and the Institution of Engineers Australia, 2005.

Research Scholarship

Chapters in Books

1. **G.M. Evans**, C.D. Rielly, J.F. Davidson and K.J. Carpenter, "Hydrodynamic Characteristics of a Gas-Inducing Impeller", in Fluid Mechanics of Mixing: Modelling, Operations and Experimental Techniques, ISBN 0-7923-1720-3, 153-161 (1993).
2. **G.M. Evans**, G.J. Jameson and B.W. Atkinson, "The Jameson Cell", in K.A. Matis, (ed.), Flotation (Science and Engineering), Marcel Dekker, ISBN 0-8246-9264-5, 331-363 (1994).
3. A.V. Nguyen, **G.M. Evans** and G.J. Jameson, "Approximate calculations of electrical double-layer interaction between spheres", in A.T. Hubbard, (ed.), Encyclopedia of Surface and Colloid Science, Marcel Dekker, 630-41 (2002).
4. A.V. Nguyen, C.M. Phan, **G.M. Evans** and G.J. Jameson, "Dynamic Adsorption of Surfactants at the Gas-Liquid Interface" in C.A. Young, J.J. Kellar, M.L. Free, J. Drelich, and R.P. King (Editors), Innovations in Natural Resource Processing, Society for Mining, Metallurgy, and Exploration, Inc. (SME), USA, 87-98 (2005).
5. A.V. Nguyen, **G.M. Evans** and G.J. Jameson, "Electrical double-layer interaction between spheres: Approximate expressions", in P. Somasundaran (ed.), Encyclopedia of Surface and Colloid Science, 2nd Edition, Taylor and Francis, New York, Vol 3, Marcel Dekker, 1971-1981 (2006).
6. R.P. Utikar, N. Darmawan, M.O. Tade, Q. Li, **G.M.** Evans, M. Glenny and V.K. Pareek, "Hydrodynamic Simulation of Cyclone Separators", in Hyoung Woo Oh (ed.), Computational Fluid Dynamics, ISBN 978-953-7619-59-6, In-Tech, Vienna. Chapter 11, 241-266 (2010).

Edited Volumes

1. **G.M. Evans** and G.J. Jameson, "Editorial, 5th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering Conference", Chemical Engineering Science, **56**, VII-IX (2001).
2. **G.M. Evans** and A.V. Nguyen (Guest Editors), Selected papers of 5th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering, Experimental and Thermal Fluid Science, **28**, 379 (2004).
3. P. Stevenson, **G.M. Evans** (Guest Editorial), "Foams in flotation and fractionation", Asia-Pacific Journal of Chemical Engineering, **4**, 179 (2009).
4. **G.M. Evans**, "Preface to Chemeca2013 Special Issue", Advanced Powder Technology, **25**, 1163 (2014).

Papers in Refereed Journals

1. **G.M. Evans**, C.D. Rielly, J.F. Davidson and K.J. Carpenter, "A Fundamental Study of Gas-Inducing Impeller Design", I.Chem.E. Symp. Ser., **121**, 137-152 (1990).
2. **G.M. Evans**, G.J. Jameson and B.W. Atkinson, "Prediction of the Bubble Size Generated by a Plunging Liquid Jet Bubble Column", Chem. Eng. Sci., **47**, 3265-3272 (1992).
3. C.D. Rielly, **G.M. Evans**, J.F. Davidson and K.J. Carpenter, "Effect of Scaleup on the Hydrodynamics of a Self-Aerating Concave Blade Impeller", Chem. Eng. Sci., **47**, 3395-3402 (1992).
4. G.D. Rigby, **G.M. Evans** and G.J. Jameson, "Influence of Fluid Pressure Field on Gas Flow Rate for a Gas-Inducing Impeller", I.Chem.E. Symp. Ser., **136**, 187-194 (1994).
5. G.D. Rigby and **G.M. Evans**, "Modelling of Gas Flow From a submerged Orifice in a Liquid Crossflow", Trans. IChemE, **73**, 234-240 (1995).
6. **G.M. Evans** and G.J. Jameson, "Hydrodynamics of a Plunging Jet Bubble Column", Trans. IChemE, **73**, 679-684 (1995).
7. **G.M. Evans**, G.J. Jameson and C.D. Rielly, "Free Jet Expansion and Gas Entrainment Characteristics of a Plunging Liquid Jet", Experimental Thermal and Fluid Science, **12**, 142-149 (1996).
8. G.D. Rigby, **G.M. Evans** and G.J. Jameson, "The Effect of Cross-Flow on the Modelling of Gas Flow From an Orifice Located in the Wake of a Bluff Body", Powder Technology, **88**, 21-26 (1996).
9. **G.M. Evans** and S.E. Forrester, "Mass Transfer in Single and Double Stage Plunging Liquid Jet Reactors", Récents Progrès en Génie des Procédés, **11(51)**, 243-250 (1997).
10. G.D Rigby, **G.M. Evans** and G.J. Jameson, "Cavity Formation Behind Ventilated Impeller Blades", Récents Progrès en Génie des Procédés, **11(52)**, 231-238 (1997).
11. S.E. Forrester and **G.M. Evans**, "Computational Modelling Study of the Hydrodynamics in a Sudden Expansion–Tapered Contraction Reactor Geometry", Chem. Eng. Sci., **52**, 3773-3785 (1997).
12. G.D. Rigby, **G.M. Evans**, and G.J. Jameson "Bubble Breakup from Ventilated Cavities in Multiphase Reactors", Chem. Eng. Sci., **52**, 3677-3684 (1997).
13. G.D. Rigby and **G.M. Evans**, "CFD Simulation of Gas dispersion Dynamics in Liquid Crossflows using Computational Fluid Dynamics", Applied Mathematical Modelling, **22**, 799-810 (1998).

14. S.E. Forrester and **G.M. Evans**, "The Importance of System Selection on Compressible Flow Analysis: Filling Vessels", Chemical Engineering Education, **32(4)**, 308-313 (1998).

15. S.F. Jones, K.P. Galvin, **G.M. Evans** and G.J. Jameson, "Carbonated Water: The Physics of the Cycle of Bubble Production", Chem. Eng. Sci., **53(1)**, 169-173 (1998).

16. S.D. Sciffer, **G.M. Evans** and J.A. Lucas, "Hydrodynamic Meniscus Profiles in Creeping Flow", Chem. Eng. Sci., **53**, 4129-4133 (1998).

17. S.F. Jones, **G.M. Evans** and K.P. Galvin, "Bubble Nucleation from Gas Cavities – A Review", Advances in Colloid and Interface Science, **80**, 27-50 (1999).

18. S.F. Jones, **G.M. Evans** and K.P. Galvin, "The Cycle of Bubble Production from a Gas Cavity in a Supersaturated Solution", Advances in Colloid and Interface Science, **80**, 51-84 (1999).

19. **G.M. Evans**, G.D. Rigby, T.A. Honeyands and Q.L. He, "Gas Dispersion through Porous Nozzles into Downflowing Liquids", Chem. Eng. Sci., **54(21)**, 4861-4868 (1999).

20. **G.M. Evans** and P.M. Machniewski, "Mass Transfer in a Confined Plunging Liquid Jet Bubble Column", Chem. Eng. Sci., **54(21)**, 4981-4990 (1999).

21. G.D. Rigby, C.D. Rielly, S.D. Sciffer, J.A. Lucas and **G.M. Evans**, "Hydrodynamics of Fluid Flow approaching a Moving Boundary", Metall. and Materials Trans. B, **31B**, 1117-1123 (2000).

22. Y. Li, I.P. Ratchev, J.A. Lucas, **G.M. Evans** and G.R. Belton, "Rate of Interfacial Reaction between Liquid Iron Oxide and CO-CO_2", Metall. and Materials Trans. B, **31B**, 1049-1057 (2000).

23. **G.M. Evans**, A.K. Bin and P.M. Machniewski, "Hydrodynamics of Large Confined Stationary Gas Bubbles in a Downward Liquid Flow", Inzynieria Chemiczna I Procesowa, **21**, 199-217 (2000).

24. A.V. Nguyen, **G.M. Evans** and G.J. Jameson, "Simple Approximate Expressions for Electrical Double Layer Interaction at Constant Moderate Potentials", J. Coll. & Inter. Sci., **230**, 205-209 (2000).

25. **G.M. Evans** and P.M. Machniewski, "Performance of a Confined Plunging Liquid Jet Bubble Column as a Gas-Liquid Reactor", Chem. Eng. Sci., **56(3)**, 1151-1157 (2001).

26. A.V. Nguyen, **G.M. Evans** and H.J. Schulze, "Prediction of van der Waals Interaction in Bubble-Particle Attachment in Flotation", International Journal of Mineral Processing, **61**, 155-169 (2001).

27. G.L. Lane, G.D. Rigby and **G.M. Evans**, "Pressure Distribution on the Surface of Rushton Turbine Blades – Experimental Measurement and Prediction by CFD", J. Chem. Eng. of Japan, **34**, 613-620 (2001).

28. R.B. Thorpe, **G.M. Evans**, K. Zhang, and P.M. Machniewski, "Liquid Recirculation and Bubble Breakup Beneath Ventilated Gas Cavities in Downward Pipe Flow, Chem. Eng. Sci., **56**, 6399-6410 (2001).

29. K.P. Galvin, S. Pratten, N. Shankar, **G.M. Evans**, S. Biggs and D. Tunaley, "Production of High Internal Phase Emulsions Using Rising Air Bubbles", Chem. Eng. Sci., **56**, 6285-6293 (2001).

30. M. Gaston, J. Reizes and **G.M. Evans**, "Modelling of Bubble Dynamics in a Venturi Flow using a Potential Flow Method", Chem. Eng. Sci., **56**, 6427-6435 (2001).

31. G.L. Lane, M.P. Schwarz, and **G.M. Evans**, "Predicting Gas-Liquid Flow in a Mechanically Stirred Tank", Applied Mathematical Modelling, **26**, 223-235 (2002).

32. A.V. Nguyen and **G.M. Evans**, "The Liquid Flow Force on a Particle in the Bubble-Particle Interaction in Flotation", J. Coll. and Interface Sci., **246**, 100-104 (2002).

33. A.V. Nguyen and **G.M. Evans**, "Axisymmetric Approach of a Solid Sphere toward a Non-Deformable Planar Slip Interface in the Normal Stagnation Flow – Development of Global Rational Approximations for Resistance Coefficients", International Journal of Multiphase Flow, **28**, 1369-1380 (2002).

34. Q. He, P. Zulli, F. Tanzil, B. Lee, J. Dunning and **G.M. Evans**, "Flow Characteristics of a Blast Furnace Taphole Stream and its Effects on Trough Refractory Wear", Iron and Steel Institute Journal International, **42(3)**, 235-242 (2002).

35. P. Harvey, A.V. Nguyen and **G.M. Evans**, "Influence of Electrical Double Layer on Coal Flotation", J. Coll. and Interface Sci., **250**, 337-343 (2002).

36. **G.M. Evans**, P. Dennis, M. Cousins and R. Campbell, "Use of Recycled Crushed Glass as a Filtration Medium in Municipal Potable Water Treatment Plants", Water Science and Technology or Water Science and Technology: Water Supply, **2(5-6)**, 9-16 (2002).

37. Q. He, **G.M. Evans**, P. Zulli, F. Tanzil and B. Lee, "Flow Characteristics in a Blast Furnace Trough", Iron and Steel Institute Journal International, **42(8)**, 844-851 (2002).

38. C.A. Jakubowski, B.W. Atkinson, P. Dennis and **G.M. Evans**, "Ozone Mass Transfer in a Confined Plunging Liquid Jet Contactor", Ozone Science and Engineering, **25**, 1-12 (2003).

39. B.W. Atkinson, G.J. Jameson, A.V. Nguyen and **G.M. Evans**, "Increasing Gas-Liquid Contacting using a Confined Plunging Liquid Jet", Journal of Chemical Technology and Biotechnology, **78(2-3)**, 269-275 (2003).

40. G. Liu and **G.M. Evans**, "Optimising Activated Sludge Growth Rate by Intensifying Hydrodynamic Forces", Journal of Chemical Technology and Biotechnology, **78(2-3)**, 276-282 (2003).

41. C.M. Phan, A.V. Nguyen, J.D. Miller, **G.M. Evans** and G.J. Jameson, "Investigations of Bubble-Particle Interactions", International Journal of Mineral Processing, **72**, 239-254 (2003).

42. C.M. Phan, A.V. Nguyen, and **G.M. Evans**, "Assessment of Hydrodynamic and Molecular Kinetic Models applied to the Motion of Dewetting Contact Line between a Small Bubble and a Solid Surface", Langmuir, **19(17)**, 6796-6801 (2003).

43. B.W. Atkinson, G.J. Jameson, A.V. Nguyen, **G.M. Evans** and P.M. Machniewski, "Bubble Breakup and Coalescence in a Plunging Liquid Jet Bubble Column", Canadian Journal Chemical Engineering, **81(3/4)**, 519-527 (2003).

44. A. Bin, P. Machniewski and **G.M. Evans**, "Generation of Gas-Liquid Dispersion in Cross-Flow Conditions", Inzynieria I Aparatura Chemiczna, **42**, No 5S, 22-24 (2003).

45. A.V. Nguyen and **G.M. Evans**, "Stream Function, Flow Separation and Force Equation for a Small Solid Spherical Particle touching a Rising Gas Bubble", J. Phys. A: Math. Gen., **36**, 9105-9117 (2003).

46. A.V. Nguyen, J. Nalaskowski, J.D. Miller, and **G.M. Evans**, "Hydrodynamic Interaction between an Air Bubble and a Particle: Atomic Force Microscopy Measurements", Experimental Thermal and Fluid Science, **28**, 387-394 (2004).

47. A.V. Nguyen and **G.M. Evans**, "Attachment Interaction between Air Bubbles and Particles in Froth Flotation", Experimental Thermal and Fluid Science, **28**, 381-385 (2004).

48. **G.M. Evans**, P.H. Scaife, B.A. Maddox and K.P. Galvin, "Using the Campus as a Classroom Concept to Highlight Sustainability Practice to Engineers and Scientists", Developments in Chemical Engineering and Mineral Processing, **12(3/4)**, 1-10 (2004).

49. S.E. Forrester A.V. Nguyen and **G.M. Evans**, "The Importance of System Selection on Compressible Flow Analysis: Discharging Vessels", Chemical Engineering Education, **38(3)**, 190-195 (2004).

50. P.M. Machniewski, A.K. Bińand **G.M. Evans**, "Bubble Formation at a Rotating Cylindrical Surface in Cross-Flowing Liquid", Canadian Journal Chemical Engineering, **82(3)**, 442-449 (2004).

51. A.V. Nguyen, and **G.M. Evans**, "Exact And Global Rational Approximate Equations For Resistance Coefficients Of A Colloidal Solid Sphere Moving Parallel To A Slip Gas-Liquid Interface In A Quiescent Liquid", Journal of Colloid and Interface Science, **273(1)**, 262-270 (2004).

52. A.V. Nguyen, and **G.M. Evans**, "Movement of Fine Particles on the Air Bubble Surface Studied using High-Speed Video Microscopy", Journal of Colloid and Interface Science, **273(1)**, 271-277 (2004).

53. D.B. Harrison, D.M. Nicholas and **G.M. Evans**, "Pitting Corrosion of Copper Tubes in Soft Drinking Waters – Corrosion Mechanism" Journal AWWA, **96(11)**, 67-76 (2004).

54. **G.M. Evans**, P.M. Machniewski and A.K. Bin, "Bubble Size Distribution and Void Fraction in the Wake Region below a Ventilated Gas Cavity in Downward Pipe Flow", Trans. IChemE, Chemical Engineering Research and Design, **82(A9)**, 1-10 (2004).

55. A.K. Bińa, P.M. Machniewski, L. Rudniak and **G.M. Evans**, "Hydrodynamics of a Rotating Gas Sparger in Cross-Flow Conditions", Inzynieria I Chemiczna i Procesowa, **25(3)**, Part 1, 709-714 (2004). (in Polish)

56. L.C Nitsche, A.V. Nguyen and **G.M. Evans**, "Globally Cohesive Drops without Interfacial Tension", Chemical Physics Letters, **397**, 417-421 (2004).

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11. S. Pratten, **G.M. Evans**, S. Biggs and K.P. Galvin, "Generation of Water in Oil Emulsions using Rising Air Bubbles", Orica Technology Conference, Surfer's Paradise, Queensland, October, (1999).

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Patents

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2. **G. M. Evans** and P.D. Machniewski, "Gas Dispersion in Downflowing Liquid Streams", PR5144 (2001).
3. K.P. Galvin, S.J. Pratten, S. Biggs and **G.M. Evans**, "Emulsion Production with Internal Plate Devices", 31637AUP00 (2001).
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Government, Industry, and Community Funded Research Grants

YEAR	GRANT BODY	PROJECT TITLE	AMOUNT
2017	ARC Discovery	DP170100277: Engineering floating liquid marbles for three-dimensional cell cultures, N-T Nguyen, AV Nguyen, Evans, Bormashenko, Gendelman, Balasuriya Ekberg	$380,000
2016	NSW DSRD	Water use in coal mining predictive tool, Evans, Galvin	$30,000
2016	ARC Linkage	LP160101181: Novel gas-liquid columns for liquefied natural gas (LNG) production, Pareek, Tade, Utikar, Evans, Byfield	$110,000 $150,000 $150,000 $410,000 (+$390,000)
2015	ARC Linkage	LP150100758: Enhancing Direct Cu Recovery through Increased Gas Processing Understanding, Bao, Evans, Nguyen (2015-2018)	$120,000 $130,000 $130,000 $380,000 (+$600,000)
	ARC Discovery	DP150100395: Surface Characteristics and Hydrodynamics in Detachment of Coarse Particles, Nguyen and Evans (2015-17)	$110,000 $115,000 $120,000 $345,000
2014	ARC Trans-formation Hub	IH130100017: The Australian Steel Manufacturing Research Hub, Gregory, Evans plus 18 other Cis, (2014-18)	$5,000,000 ($5,000,000)
	ARC Discovery	DP140101089, "Flotation in high salt concentration: resolving critical knowledge gaps relating the ion effect on bubble production and behaviour", Nguyen, Evans, Dang, (2014-16)	$187,743 $139,843 $177,418 $505,004
2013	ARC Linkage	LP130100700: A green technology for liquefied natural gas (LNG) regasification (Pareek, Evans, Tade, McConochie) (2013-16)	$450,000 ($300,000)
2012	ARC LIEF	LE120100109: A facility for non–destructive quantification of coal structures, composition and percolation fluid flows in energy and environmental applications (with 15 others)	$370,000 ($515,000)
	ARC LIEF	LE120100211: 3D Gamma Ray Tomography for Multiphase Flow Characterization (with 11 others)	$230,000 ($210,000)
2011	ARC Linkage	LP110200920: Enhanced Carbon Removal in Secondary Steel Refining (Evans, Doroodchi) (2011-14)	$230,000
	ARC Linkage	LP110100498: Enhancing the position of Australian iron ore exports through understanding and altering the coalescence phenomenon during sintering (Loo, Lucas, Evans, Heikkinen, Mald.) (2011-13)	$300,000
	ARC Linkage	LP110100717: Vaporization of Heavier Gas Oil in Fluid Catalytic Cracking Riser (Pareek, Evans, Tade, Utikar) (2011-13)	$209,000 ($120,000)
2010	ARC LIEF	LE100100155: High-Speed Particle Image Velocimetry and Laser-Induced Fluorescence Facility (with 17 others)	$495,000
2009	ARC LIEF	LE0989675: Interface-specific facility for quantifying adsorption and structures at particulate interfaces (with 15 others)	$180,000

	ARC LIEF	Electron Microscopes for Nanometer-scale Imaging/Microanalysis in the Materials, Biological, Physical, Engineering and Chemical Sciences (with 32 others)	$650,000
2008	ARC Discovery	Transport phenomena in foam fractionation (with P Stevenson) (2008-2010)	$475,697
	ARC Discovery	Force Interactions in Packed and Fluidised Beds at Micro-Scale Operation (with E Doroodchi)	$380,000
	ARC Linkage	Slag entrainment and dispersion in continuous slab casting (with R Serje) (2008-2010)	$532,371
	ARC Linkage	Coarse Grid Eulerian-Eulerian Multiphase Model For Fluid Catalytic Cracking Unit (with V Pareek, M Tade, Q. Li) (2008-2010)	$335,000
2007	CRC SRP	Scholarship support for Steve Mohr (Peak Oil)	$45,000
2006	ARC Discovery	Effect of Saline Water on Flotation Processes (with AV Nguyen) (2006-2010)	$810,000
	Ncle RC (Ind)	Micro-Reactor Study (with AV Nguyen and E Doroodchi)	$48,181
2005	ARC Discovery	Drag Force on Bubbles and Particles in Turbulent Flows (with Schwarz) (2005-2007)	$288,000
	ARC Linkage	Inter-metallic Inclusion Reduction in Continuous Metallic Coating (with Willis) (2005-2007)	$476 917
	ARC Linkage	Ozone-Enhanced Particle Removal in Water Treatment (with Nguyen, Dennis and Yan) (2005-2007)	$433 008
	ARC LIEF	A high-speed PIV Facility for Kinematic Investigation of Rapid Transient and Pulsatile Fluid Flows (with 6 others)	$251 000
	Ncle RC (Proj)	Prediction of Two Phase Flow Regime Transition using Drift Flux Analysis	$8 691
	Ncle RC (Ind)	SEN Water Modelling: BlueScope Steel (with Q He)	$45, 877
2004	Ncle RC (Proj)	A novel Wavelet-Accelerated Particle-Based Approach to Describing Complex Dynamics	$14 141
	Ncle RC (Proj)	Influence of Dynamic Surface Tension and Surfactant Adsorption on the Bubble-Particle Contact Interaction (with Nguyen)	$8 485
	ARC Linkage	Role of Reactive Particles in Explosive Emulsions (with Nguyen and Goodridge) (2004-2006)	$270 000
	ARC LIEF	Atomic Force Microscopy for Soft interfaces (with 12 others)	$745 124
	Ncle RC (Proj)	Turbulence Control for Improved Steel Cleanliness (with He and Nguyen).	$12 650
	Ncle RC (Vis)	Jiri Skvarla (Technical University of Kosice, Slovak Republic).	$5 345
	Ncle RGC (Trav)	Conference Travel Grant (Warsaw, Poland, August)	$2 400
2003	ARC Linkage	Integration of Life Cycle Analysis, ExternE, and Economic Models to Sustainable Regional Development (with Scaife and Wibberley) (2003-2005).	$98 289
	ARC LIEF	Integrated Facility for Interfacial Rheology (with 11 others)	$435 876
	Ncle RC (Proj)	Nanoscale Structures of Surface-Active Reagents at Solid-Liquid and Gas-Liquid Interfaces and their Influences on Interfacial Properties (with Nguyen) (2003-2005).	$29 015
	Ncle RC (Proj)	Influences of Fluid Forces on Activated Sludge Behaviour.	$12 000
	OneSteel	Turbulence Control for Improved Steel Cleanliness (with He and Nguyen).	$55,890
	Ncle RMC (Trav)	Conference Travel Grant (Vancouver, Canada, August).	$2 400
2002	ARC Linkage	Free Surface Instability and Gas Entrainment during Blast Furnace Drainage (Sole Investigator) (2002-2004).	$192 000
	ARC Linkage	Combined Ozonation-Flotation for the Treatment of Potable Water (with Moghtaderi and Biggs) (2002-2004).	$257 000
	ARC LIEF	Integrated Particle Image Thermometry/Velocimetry Facility (with 15 others).	$345 000
	ARC LIEF	In-Situ Spectroscopy of Particles and Material Interfaces (with 8 others; University of South Australia Key Institution).	$675 000
	Ncle RMC (Proj)	Recirculation Below a Ventilated Cavity in a Confined Downflowing Liquid (with S Sciffer).	$14 480
	Ncle RMC (Proj)	Surface Shear Viscosity in Surfactant Solutions (with AV Nguyen).	$16 318

	Ncle RMC (Vis)	Ludwig Nitsche (University of Illinois).	$5 132
	BHP Industry	Integration of LCA, ExternE, and Economic Models to Sustainable Development (with P Scaife and L Wibberley).	$25 000
	BHP Industry	Tundish Vortex Breaker Study (with Q He).	$11 520
2001	Industry	Sustainable Resource Processing (with J Herbertson, J Lucas)	$145 000
	ARC RIEF	High-Speed Digital Video Facility for Transient Flow Analysis (with 14 others).	$445 000
	ARC LG	Three-Phase Contact Expansion between Air Bubbles and Mineral Surfaces (with AV Nguyen) (2001-2003).	$138 000
	Ncle RMC (Proj)	Thinning and Rupture of Intervening Liquid Films between Gas and Solid Phases (with AV Nguyen).	$18 000
	Ncle RMC (Trav)	Conference Travel Grant (Toulouse, France, May).	$2 500
2000	DEETYA (S/L)	The UNICHE Project (with 5 others, 2000-2002).	$1 650 000
	ARC SRC	SRC for Multiphase Processes (with 4 others, 2000-2002).	$1 750 000
	Ncle RMC (Ind)	The Use of Immersed Membranes in Water Treatment Processes (with Moghtaderi and Biggs)	$18 500
	Ncle RMC (Proj)	Bubble and Particle Motion in Turbulent Liquids.	$12 000
	Ncle RMC (Vis)	John Smith (Surrey University)	$4 267
1999	ARC RIEF	Particle Characterisation Facility (with S Biggs and 5 others).	$950 000
	ARC LG	Heat and Momentum Transfer in Boiling Liquids (with JA Reizes) (1999-2001).	$189 000
	ARC LG	Fluid-Particle Interactions with Emphasis on Free Surface Flows (with C Fletcher) (1999-2001).	$189 000
	ARC SPIRT	Continuous Production of Concentrated Emulsions (with S Biggs and K Galvin).	$289 002
	ARC SG	Bubble Formation and Jetting Phenomena at Elevated Temperatures and Pressures (with K Galvin).	$18 000
	Ncle RMC (Proj)	Droplet Formation in Liquid-Liquid Systems (with K Galvin) (1999-	$48 000
	Ncle RMC (Vis)	01).	$4 937
	Ncle RMC (Trav)	Professor AB Pandit (University of Mumbai).	$2 400
		Conference Travel Grant (Chandigarh, India, December).	
1998	ARC RIEF	Laser Facility for Diagnostics in Multiphase Flows (with 6 others).	$835 000
	ARC SPIRT	Ozonation of Potable Water (Sole Investigator) (1998-2000).	$338 609
	ARC SG	High Temperature and Pressure Fluidisation (with K Galvin).	$15 000
	ARC SG	Bubble Nucleation in the Bulk (with K Galvin).	$13 000
	BHP Industry	Coating Fundamentals (with J Lucas and J O'Connor).	$100 000
	ICA Industry	Cuprosolvency in Potable Water (Sole Investigator) (1998-1999).	$45 000
	ORICA Industry	Bubble Formation and Growth in Visco-elastic Emulsions (with K Galvin).	$10 000
1997	ARC SRC	SRC for Multiphase Processes (with 9 others, 1997-1999).	$1 950 000
	ARC Collab	Fluid Mechanics and Heat Transfer of High speed Coating Processes (with J Lucas, 1997-9).	$316 000
	ARC APA(I)	Pitting Corrosion and Blue Water Formation in Potable Water (with D Nicholas and B King, 1997-9).	$78 540
	ARC Conf Supp	GLS-5 Reactor Engineering Conference (with G Jameson).	$2 000
	Ncle RMC (Proj)	Influence of Fluid Shear and Minimum Cell Viability on Bioprocess Design and Operation (with J Lucas).	$7 000
	Ncle RMC (Proj)	The Physics of the Cycle of Bubble Production (with K Galvin).	$14 000
	Ncle RMC (Trav)	Travel Grant (Japan).	$2 400
	BHP Industry	Laser Doppler Velocimetry (with J Lucas).	$100 000
	ICA Industry	Cuprosolvency in Potable Water.	$10 000
	ICI Industry	Scaling in Emulsion Production (with K Galvin).	$3 000
1996	ARC LG	Gas Dispersion from Ventilated Cavities (1996-8).	$175 937
	BHP Industry	High Speed Coating Processes (with J Lucas).	$40 000
	Ncle RMC (Proj)	Influence of Surface Active Species on the Mass Transfer of Carbon Dioxide (with K Galvin).	$11 000
1995	ARC LG	Fluid Mechanics and Mass transfer in Plunging Liquid Jets (Sole Investigator) (1995-1997).	$166 535
	Ncle RMC	Aeration of Activated Biological Sludge.	$14 000

	LMCC Industry	Stability of Lead in Soil (with P Middlebrook).	$3 000
1994	Ncle RMC ARC SG Ncle RMC (Trav)	Mass Transfer in a Plunging Liquid Jet Bubble Column. Bubble Formation and Growth in Solutions Supersaturated with Carbon Dioxide (with K Galvin). Travel Grant (England).	$8 000 $15 000 $1 833
1993	Ncle RMC BHP Industry	Bubble Formation in a Transverse Flow. Particle Image Velocimetry (with J Lucas).	$11 000 $10 000
1992	Ncle RMC Ncle RMC	Bubble Characteristics of Gas-Inducing Impellers. Travel Grant (USA).	$8 000 $1 250
1990	ARC LG	Fluid Dynamics of a New Device for Mineral Flotation (with G Jameson, 1990-1991).	$170 000
1988	Ncle RMC (Proj)	Hydrodynamics of Bubble Columns.	$5 000
1986	ARC LG	Bubble Production in Stirred Vessels (with G Jameson, 1986-1989)	$74 000

Raghvendra Gupta

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raghvendra.gupta@gmail.com

Qualifications

- PhD, 2010, Chemical Engineering, The University of Sydney, Australia.

Thesis: *CFD simulations of gas-liquid flow in microchannels.*

- M. Eng., Aerospace Engineering, 2004, Indian Institute of Science (IISc), Bangalore, India.

GPA: 6.8/8.0; Dissertation*: Numerical investigations into the flow field of a liquid rocket engine.*

- B. Tech., Chemical Engineering, 2002, Harcourt Butler Technological Institute (HBTI), Kanpur, India.

Professional Experience

Jul 2014-present:	Assistant professor, Chemical Engineering, IIT Guwahati.
Sep 2013-Jul 2014:	Assistant professor, Chemical Engineering, BITS Pilani, K. K. Birla Goa campus.
Jan 2012- Aug 2013:	Scientist, Institute of High Performance Computing, A*STAR, Singapore.
May 2010-Dec 2011:	Research Associate, The University of Sydney, Australia.
Mar 2007-Feb 2010:	Research Assistant, The University of Sydney, Australia.
Sep 2004- Aug 2006:	Assistant System Engineer (CFD Engineer), TCS Limited, Bangalore

Membership of Professional Bodies

- 2016- Life Member, Indian Institute of Chemical Engineers (IIChE)
- Member, Indian Institute of Engineers

Research Interests

My research interests are based around understanding transport processes in chemical and mineral processing and biomedical applications. Most of the problems I am working upon currently are on multiphase flows, microfluidics and interfacial phenomena. Till date, his main contribution has been in developing an understanding of flow and heat transfer in gas-liquid and liquid-liquid Taylor flow regime in microchannels. Recently, he is working on developing a mutiscale modeling approach for bubble, droplet and particle interaction. He also teaches a course on biofluid mechanics and plan to apply his microfluidics and multiphase flow knowledge to understand the biological flow problems and vice versa.

Invited Talks

- Invited Speaker, National Workshop on Fluid Flow & Heat Transfer in Microchannels and Nanochannels 2016, Department of Chemical Engineering, Gayatri Vidya Parishad College of Engineering, Visakhapatnam
- Session speaker, Short Term Training Program (STTP) on Recent Advances in Precision Manufacturing, SVERI College of Engineering, Pandharpur, 28 Nov, 2013.
- Invited Speaker, International conference on mathematical techniques in engineering applications, Oct. 24-25, 2013.
- Invited Speaker, Ninth ANSYS Convergence conference, Singapore, May 15, 2013.
- Centre of Smart Interfaces (CSI), Technische Universität (TU), Darmstadt, Nov 29, 2012.
- Department of Chemical Engineering, IIT, Delhi, July 16, 2011.

Research and Consultancy Grants

- DST-SERB Fast Track Grant (Young Scientist Award), DST-SERB
  Title: *Transport processes in slug-annular and annular flow regimes in microchannels*
- Consultancy Project, Tata Steel; Title: *CFD Study of Mould Flow Patterns*
- Start-up Grant IIT Guwahati; Title: *Inertial focusing of particle and droplets in microchannels*

Research Supervision

- Current: Supervising 6 PhD (4 jointly), 2 M. Tech. students at present.
- Graduated: 3 postgraduate (M Tech) students
- Also supervise a number of B Tech students for final year thesis, summer traineer and informal projects.

Teaching

- PG courses on Biofluid Mechanics, Mathematical Methods in Chemical Engg, Petroleum Laboratory.
- UG level courses on Chemical Reaction Engineering, Thermodynamics, Heat Transfer

Invited Talks

- Invited Speaker, National Workshop on Fluid Flow & Heat Transfer in Microchannels and Nanochannels 2016, Department of Chemical Engineering, Gayatri Vidya Parishad College of Engineering, Visakhapatnam
- Session speaker, Short Term Training Program (STTP) on Recent Advances in Precision Manufacturing, SVERI College of Engineering, Pandharpur, 28 Nov, 2013.
- Invited Speaker, International conference on mathematical techniques in engineering applications, Oct. 24-25, 2013.
- Invited Speaker, Ninth ANSYS Convergence conference, Singapore, May 15, 2013.
- Centre of Smart Interfaces (CSI), Technische Universität (TU), Darmstadt, Nov 29, 2012.
- Department of Chemical Engineering, IIT, Delhi, July 16, 2011.

Short Term Courses Organized

- Multiphase Flow in Oil and Gas Industry (TEQIP), March 2016, IIT Guwahati.
- Transport Processes and Optimisation in Polymers (TEQIP), Dec 2014, IIT Guwahati.
- Multiphase Flow Reactors Insights through Experimental and CFD Techniques (QIP), Dec 2014, IIT Guwahati.

Recognitions

1. Two Articles appeared in Chemical Engineering Science were among the most cited articles after 5 years.
2. CSI (Client satisfaction Index) of 5/5 for the first project (client: DuPont, USA) at TCS.
3. All India rank 4 (99.91 Percentile) in GATE-2002 in the Chemical Engineering discipline.
4. First rank in district (among 5000+ students) in year 12.

Scholarships

- Henry Bertie and Florence Mabel Gritton post-graduate research scholarship, 2006-2010.
- Faculty scholarship, School of Chemical and Biomolecular Engineering, University of Sydney, 2006-2010.
- Ministry of Human Resources Development (MHRD) scholarship, government of India, 2002-2004.
- Integrated Scholarship, Government of Uttar Pradesh, India, 1992-1996.
- Junior Highschool Scholarship, Government of Uttar Pradesh, India, 1989-1992.

Synergistic Activities

- Reviewer for Physics of Fluids, Chemical Engineering Science, Chemical Engineering Journal, Computational Thermal Sciences, Journal of Mechanical Behaviour of Biomedical Materials.
- Member of Indian Institute of Chemical Engineers, The Institute of Engineers (India)

List of Publications

Refereed Journals*

2017

1. Kumar, N., Kumari, S., Gupta, R., Hydrodynamics of short bubbles in gas-liquid flow in microchannels, Submitted, Chemical Engineering Science.

2016

2. Gupta, R., Turangan, C. K., Manica, R.,"Oil-water core-annular flow in vertical pipes: A CFD study", The Canadian Journal of Chemical Engineering, 94, (2016), 980-987.

3. Kumar, N., Kumari, S., **Gupta, R.**," A Computational study on the effect of gas-liquid ratio on the wall shear stress in slug flow in capillary membranes", Chemical Product and Process Modelling, Under Revision

2014

4. Manica, R., E. Klaseboer, **R. Gupta**, M.H.W. Hendrix, C.-D. Ohl and D.Y.C. Chan. "Modelling film drainage of a bubble hitting and bouncing off a surface, (2014) Applied Mathematical Modelling, 38, 4249-4261.

5. Klaseboer, E., **Gupta, R.**, Manica, R.,"An extended Bretherton model for long Taylor bubbles at moderate Capillary numbers",(2014), Physics of Fluids, 26, 032107.

6. Leung, S.S.Y., **R. Gupta**, D. F. Fletcher and B. S. Haynes. "Experimental investigation of Taylor and intermittent slug-annular/annular flow in microchannels."(2014), Experimental Heat Transfer. 27, 360-375.

2013

7. Manica, R., M.H.W. Hendrix, **R. Gupta**, E. Klaseboer, C.-D. Ohl and D.Y.C. Chan. "Effect of hydrodynamic film boundary conditions on bubble-wall impact", Soft Matter, (2013), 9, 9755-9758.

8. Gupta, R., R. Manica, S.S.Y. Leung, D. F. Fletcher, B. S. Haynes, "Three-dimensional effects in Taylor flow in circular microchannels.", International Water Journal La Houille Blanch, (2013) 60-67.

9. Gupta, **R.,** S.S.Y. Leung, R. Manica, D. F. Fletcher and B. S. Haynes. "Hydrodynamics of liquid-liquid Taylor flow in microchannels." Chemical Engineering Science, 92(2013) 180-189.

2012

10. Leung, S.S.Y., **R. Gupta**, D. F. Fletcher and B. S. Haynes. "Effect of flow characteristics on Taylor flow heat transfer.", Industrial and Engineering Chemistry Research, 51(2012) 2010-2020.

11. Leung, S.S.Y., R. Gupta, D. F. Fletcher and B. S. Haynes. "Gravitational effect on Taylor flow in horizontal microchannels.", Chemical Engineering Science, 69(2012) 553-564.

12. Asadolahi, A.N., S.S.Y. Leung, **R. Gupta**, D. F. Fletcher and B. S. Haynes. "Validation of a CFD model of Taylor flow hydrodynamics and heat transfer." Chemical Engineering Science, 69 (2012), 541-552.

2011

13. Asadolahi, A.N., **R. Gupta**, D. F. Fletcher and B. S. Haynes. "CFD Approaches for the simulation of hydrodynamics and heat transfer in Taylor flow." Chemical Engineering Science, 66 (2011), 5574-5584.

2010

14. Gupta, R., D. F. Fletcher and B. S. Haynes. "Taylor flow in microchannels: A review of experimental and computational work.", The Journal of Computational Multiphase Flows, 2 (2010), 1-31.

15. Gupta, R., D. F. Fletcher and B. S. Haynes. "CFD modelling of heat transfer in the Taylor flow regime." Chemical Engineering Science, 65 (2010), 2094-2107.

2009

16. Gupta, R., D. F. Fletcher and B. S. Haynes. "On the CFD modeling of Taylor flow in microchannels." Chemical Engineering Science, 64 (2009), 2941-2950.

2008

17. Gupta R., P. E. Geyer, D. F. Fletcher and B. S. Haynes, "Thermohydraulic performance of a periodic trapezoidal channel with a triangular cross-section", International Journal of Heat and Mass Transfer, 51 (2008), 2925-2929.

Conference Proceedings:

1. Kumari, S., Gupta, R., Flow and heat transfer in slug flow in microchannels at low bubble/droplet volumes, International Conference on Gas–Liquid and Gas–Liquid–Solid Reactor Engineering, Aug 2017, Brussels, Belgium, accepted.
2. Lanjewar, T., Gupta, R., An Experimental Study of Bubbly Flow in a Horizontal Channel, CompFlu 2016, Dec 2016, poster presentation, Hyderabad.
3. Kumari, S., Gupta, R., Interaction between short and long bubbles/droplets in microchannels, CompFlu 2016, Dec 2016, poster presentation, Hyderabad.
4. Mishra, D. K., Gupta, R., CFD simulation of flow in a bubble column, CompFlu 2016, Dec., 2016, Poster presentation, Hyderabad.
5. Kumari, S., Kumar, N., Gupta, R., Hydrodynamics of slug flow in capillaries: Cases of low bubble volumes and low slug volumes, International Conference on Microreaction Technology (IMRET) 2016, 12-14 Sep 2016, Oral presentation, Beijing, China.
6. Kumar, N., Kumari, S., Gupta, R., A computational study on the effect of gas-liquid ratio on wall shear stress in slug flow in capillary membranes, DAE-BRNS Symposium on Emerging Trends in Separation Science and Technology (SESTEC), May 2016, Oral presentation (Full paper submitted), Guwahati, Assam, India.
7. Srinivas, P., Mishra, A., Gupta, R., Korath, J. M., CFD modelling of flow in a continuous casting mould, Indo-German Workshop on Advances in Materials, Reaction and Separation Processes, Feb 2016, poster presentation, Guwahati, India (The student was awarded third prize for the poster)
8. Agnihotri, O., Gupta, R., Jan 2016, Computational modelling of stratified oil-water flow, poster presentation, CompFlu 2016, Pune, India.
9. Srinivas, P., Mishra, A., Gupta, R., Korath, J. M., CFD methodology to model flow in a continuous casting mould, Chemical Engineering Congress (CHEMCON), Dec 2015, poster presentation, Guwahati, India.
10. Gupta, R., Modelling of gas-liquid annular flow in pipelines, IUTAM Symposium on Multiphase Flows with Phase Change: Challenges and Opportunities, poster presentation, Dec 2014, Hyderabad, India.
11. Manica, R., M.H.W. Hendrix, E. Tjoa, **R. Gupta**, E. Klaseboer, C.-D. Ohl and D.Y.C. Chan. "A dual view of bubble impact", oral presentation, International Conference on Multiphase Flow, May 26-31, 2013, Jeju, South Korea.
12. **Gupta R.**, J. Gusti, C. Turangan, R. Manica, "CFD modeling of liquid-liquid annular flow.", poster presentation, International Conference on Multiphase Flow, May 26-31, 2013, Jeju, South Korea.
13. Manica, R., E. Klaseboer, **R. Gupta**, M.H.W. Hendrix, C. Ohl, D.Y.C. Chan, "Modelling film drainage of a bubble hitting and bouncing off a surface", oral presentation, Ninth International Conference on Computational Fluid Dynamics in the Minerals and Process Industries, Dec 10-12, 2012, Melbourne, Australia.
14. **Gupta, R.**, R. Manica, S.S.Y. Leung, D. F. Fletcher, B. S. Haynes, "Three-dimensional effects in Taylor flow in circular microchannels.", oral presentation, Third European Microfluidics Conference, Dec 3-5, 2012, Heidelberg, Germany.
15. **Gupta, R.**, D. F. Fletcher and B. S. Haynes, "On the CFD modelling of annular flow in microchannels", oral presentation, Second Australian and New Zealand Micro and Nanofluidics Symposium, April 28-29, 2011.
16. Leung, S.S.Y., **R. Gupta**, D. F. Fletcher and B. S. Haynes, "Flow and heat transfer characteristics of Taylor flow in microchannels", oral presentation, Second Australian and New Zealand Micro and Nanofluidics Symposium, April 28-29, 2011.
17. Leung, S.S.Y., **R. Gupta**, D. F. Fletcher and B. S. Haynes, "Gravitational effects on Taylor flow in horizontal microchannels", poster presentation, Second Australian and New Zealand Micro and Nanofluidics Symposium, April 28-29, 2011.

18. Asadolahi, A.N., **R. Gupta**, D. F. Fletcher and B. S. Haynes, "CFD methodologies for the modelling of hydrodynamics and heat transfer in Taylor flow", poster presentation, Second Australian and New Zealand Micro and Nanofluidics Symposium, April 28-29, 2011.

19. **Gupta, R.**, D. F. Fletcher and B. S. Haynes. "On the importance of buoyancy in Taylor flow in horizontal microchannels", oral presentation, International Conference on Multiphase Flow, Tampa, USA, June, 2010.
20. **Gupta, R.**, D. F. Fletcher and B. S. Haynes. "Heat Transfer Modelling for Taylor Flow in Microchannels." poster presentation, IMRET11, Kyoto, Japan, March, 2010.
21. **Gupta, R.**, D. F. Fletcher and B. S. Haynes. "Numerical challenges in the modelling of multiphase flow in microchannels", poster presentation, Australian ANSYS-Users Conference, Sydney, Australia, Nov 2008.