GIAN Course on Advances in Multiphase Processes

28th November, 2016 – 06th December, 2016

1. Overview

Multiphase flow processes are very common in both natural and engineered systems that it is important to understand the underlying physical phenomena and dynamical response of such system using both computational and experimental techniques. Virtually, every processing technology must deal with multiphase flow, and clearly the ability to predict the flow behavior of these processes is central to the efficiency and effectiveness of those processes. Multiphase flow, in broad sense, is a flow in which two or more phases of matter are dynamically interacting leading to a general classification of systems such as Gas/ Liquid, Gas/ Solid, Liquid/Solid or immiscible Liquid/ Liquid. A variety of flow regimes do exist in response to changes in volume fraction of dispersed phase and dynamics of momentum exchange across interfaces.

Common challenges in chemical process industry includes selection of right reactor type for given chemistry, determination of environment impact with improved accuracy, reduction in the risk of implementation of new technology and safety.

A single approach is not viable to treat such a wide range of behavior. When handling large scale problems, sub scale models, which are increasingly based on fundamentals, could become building blocks for large scale frame work. The major challenges on computational platform is creation of efficient framework for linking multi-scale models. Typically used multiphase reactors types are viz., Stirred Tank, Bubble Column, Packed Beds, Fluidized Beds, Risers and Micro Reactors of various types. The methods used in modelling of multiphase flows encompass DNS, LES, Lagrange-Euler, Mixture Model and N- Fluid (Euler – Euler) Model.

The course will cover the concepts associated with multiphase flow processes, modeling and simulation methods and use of CFD for various multiphase applications. The performance evaluation of the multiphase processes involves extensive modeling at micro and macro level fluid/fluid or fluid/solid interactions. The course will teach fundamentals in modeling and review of various applications such as Bubble Columns, Fluid Beds and Packed Beds etc.

2. Objectives

At the completion of this course, the **Participant** should be able to accomplish the following.

- Identify challenges and complex nature of multiphase flow processes.
- Development of various modelling frameworks to understand multiphase flow processes
- Use of computational tools to solve multiphase flow problems.
- Enable Process Innovation through Computation

3. Lecture Schedule

Day	Date	Time	Topic
1	28-11-2016 (Monday)	8:30-9:30	Registration & Inauguration
		9:30-11:00	**Lecture**: Nature of multiphase flows
		11:30-13:00	Open Discussion - Q&A
		14:00-15:30	**Lecture**: Equations of motion – incompressible NSE
		16:00-17:30	Open Discussion - Q&A
2	29-11-2016 (Tuesday)	**9:00-10:30**	**Lecture**: Hydrodynamic stability & Origins of Turbulence
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Concepts of averaging – time and volume averaging
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: Closures models –how do we get them
		16:30-17:15	Open Discussion - Q&A
3	30-11-2016 (Wednesday)	**9:00-10:30**	**Lecture**: Turbulence models - closures
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Multiphase models - closures
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: What is DNS? Current status for getting closure info
		16:30-17:15	Open Discussion - Q&A
4	01-1-2016 (Thursday)	**9:00-10:30**	**Lecture**: Measurement techniques as sources of closure info
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Introduction to numerical algorithms
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: Review of discretization schemes
		16:30-17:15	Open Discussion - Q&A
5	02-12-2016 (Friday)	**9:00-10:30**	**Lecture**: Numerical stability – CFD
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Gas-Solid flows - Fluidization
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: Gas-Liquid Flows - Bubble columns
		16:30-17:15	Open Discussion - Q&A
6	03-11-2016 (Saturday)	**9:00-10:30**	**Lecture**: Solid-Liquid Flows – Slurry flows
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Packed beds/Sieve trays- distillation
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: Population balance modeling concepts
		16:30-17:15	Open Discussion - Q&A
7	05-12-2016 (Monday)	**9:00-10:30**	**Lecture**: Multi-physics modeling concepts - coupling
		10:45-11:30	Open Discussion - Q&A
		11:30-13:00	**Lecture**: Data driven models – what are the opportunities?
		14:00-14:45	Open Discussion - Q&A
		14:45-16:15	**Lecture**: EPIC- A framework for enabling Process innovation
		16:30-17:15	Open Discussion - Q&A

8	06-12-2016 (Tuesday)	**9:30-11:30**	Test
		12:00-13:00	Certificate Distribution and Closing Ceremony

Modules	• **Introduction of concepts, methods and tools** • **Simulation methods and related modelling and numerical methods** • **Case Studies**
You Should **Attend If…**	• **Practicing Engineers, Researchers from Industries, government organizations including R&D laboratories** • **Students at all levels (UG/ PG/ PhD) or Faculty from reputed academic institutions and technical institutions**
Fees	**Participants from abroad:** US $300 **Industry/ Research Organizations:** Module cost: Rs. 20000/- **Academic Institutions:** Module Cost: Rs. 4000/- (Faculty) Module Cost: Rs. 2000/- (Research Scholars) The above fee include all instructional materials, computer use for tutorials, 24 hr free internet facility. The participants will be provided with single bedded accommodation (sharing basis double room) on payment basis in Hostel/ Institute Guest House.
How to Register	The interested participants have to remit the necessary course fee online to the bank account as per the details given below and mail the transaction details to: sarat@nitt.edu **Details of Bank Account:** Name of the Beneficiary: THE DIRECTOR NIT TRICHY Name of the Bank: STATE BANK OF INDIA Branch Code: 1617 Beneficiary Account no.: 10023883042 Bank MICR Code: 620002009 Bank IFSC Code: SBIN0001617
Accommodation	The participants may be provided with hostel accommodation, depending on the availability and on payment basis. Request for hostel accommodation may be submitted through e-mail to the Course Co-ordinator.

4. Teaching Faculty

Dr. **Krishnaswamy Nandakumar**, nicknamed "kumar", joined the Cain Department of Chemical Engineering at the Louisiana State University as the Gordon A. and Mary Cain Endowed Chair Professor in August 2009. Prior to this, he held the position of GASCO Chair Professor at the Petroleum Institute during 2007-2009 in the Chemical Engineering Program. He has had a distinguished academic career at the University of Alberta, since 1983 excelling in both teaching and research as evidenced by the numerous awards that he has received.

His main research interests are in the area of multiphase flows, computational fluid dynamics, computer aided modeling of chemical, mineral, polymer and electrochemical processes, including fuel cells.

He has been an Alexander von Humboldt Research Fellow in Erlangen, Germany during 1989-90, a Visiting Professor at the Indian Institute of Science, Bangalore during 1996-97, and a Visiting Professor at the National University of Singapore during 2002.

His research has been supported by NSERC Discovery, Strategic and Collaborative Research & Development grants and by industries such as Syncrude Canada, DuPont Canada and Koch-Glitsch. He has given training courses on computational fluid dynamics to industry.

He has given talks at various industrial laboratories around the world, including lectures on packed column modeling at Raschig Gmbh in Germany, Sulzer in Switzerland, BOC Gases in NJ, USA, Engineers India Ltd. in New Delhi, Indian Oil Corp. in New Delhi and Defense Science and Technology Organization, Australia. He served as the Editor in Chief of the Canadian Journal of Chemical Engineering during 2005-2009

Dr. J. Sarat Chandra Babu is Professor in Chemical Engineering Department at National Institute of Technology, Tiruchirappalli, Tamilnadu. His research interests are Particulate Material Characterization, Handling and processing; multiphase flow systems; and process modeling. He has been involved with sponsored projects and industrial consultancy dealing with gas-solid systems.

Dr. T. K. Radhakrishnan is Professor in Chemical Engineering Department at National Institute of Technology, Tiruchirappalli, Tamilnadu. His research interests are Fluid Dynamics, Process Modeling and Simulation, Model Based Control, Control relevant Identification and Process Systems Engineering. He has been involved with sponsored projects and industrial consultancy in process control.

Course Coordinators

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