GIAN-Global Initiative on Academic Network Course on

TWO-PHASE FLOW AND PHASE CHANGE PROCESSES IN CONVENTIONAL AND MICROSCALE CHANNELS: FUNDAMENTALS AND HEAT EXCHANGER DESIGNING TOOLS

14th to 19th February 2022

Overview

Liquid-gas two-phase flows are present in several processes and equipment related to the use of energy and its conversion. However, this subject is only marginally covered in undergraduate courses due to the high complexity of the phenomena that are involved. Therefore, it is expected through this course that the graduate students end engineers, more mature than the undergraduate students, learns the two-phase flow and phase-change fundamentals and also become familiarized with the most up-to-date prediction methods available in literature for the design and optimization of heat exchangers.

Nowadays, it is a fact that increasing the capacity to dissipate and absorb heat in confined space conditions is a primary challenge for the evolution of technologies in various areas, especially those associated to solar energy and thermal management of electronic devices with high processing capacity. Phase-change processes associated with the microchannels technology seem to attend such demand of high heat transfer rates under confined conditions and low temperature differences.

In 1997, the Kyoto Protocol has established the gradual replacement of HFCs by refrigerants with global warming potential (GWP) less than 150. In this context, a new demand was generated for fluids that could substitute the HFCs with the natural refrigerants (hydrocarbons, CO2 and ammonia) becoming prominent candidates.

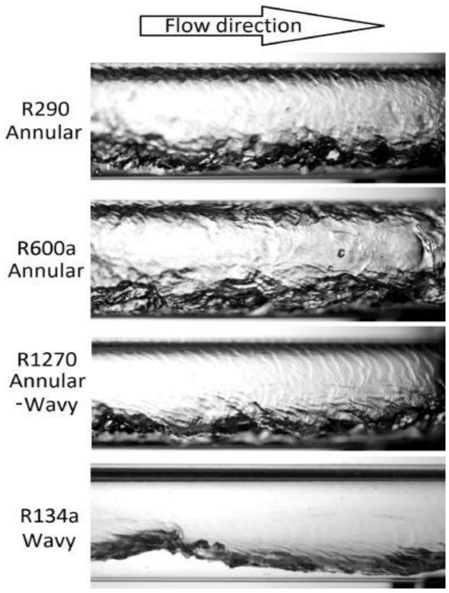
In this context, additional care is exercised in the present course in order to present the prediction methods developed for microchannels and natural refrigerants.

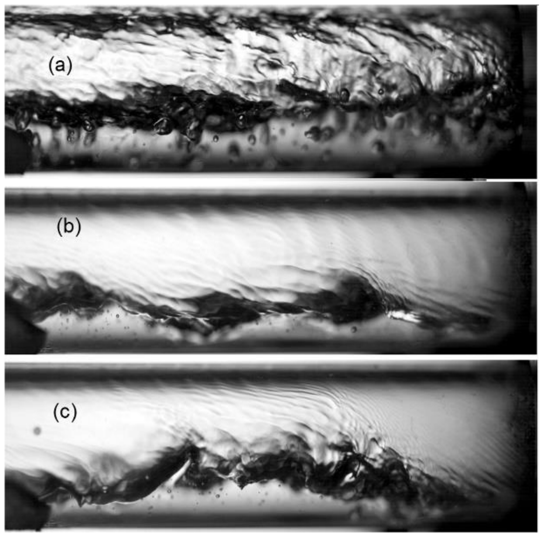
Objectives of the course:

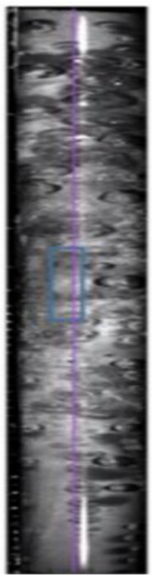
- Exposing the participants to the fundamentals of two-phase flow and phase-change processes focusing on heat transfer aspects and the associate applications,
- Present to the participant the most up-to-date prediction methods available in literature proposed to evaluate the void fraction, pressure drop, heat transfer coefficient and critical heat flux for two-phase flows and phase change process focusing on small dimension

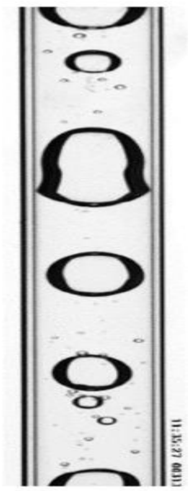
channels and natural refrigerants,

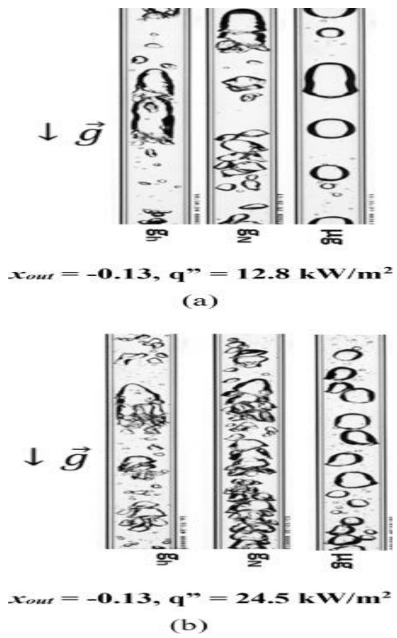
- Develop the capability of the participants to identify and implement as designing tools of heat exchanger and dissipator the most up-to-date prediction methods for two-phase flow and phase change processes.











Details of the course:

Duration: February 14 – February 19, 2022 (6 days): 12 hrs lectures and 4 hrs Tutorials

Tentative lectures Schedule

February 14 - Monday
Lecture 1 – Two-Phase Flow Fundamentals: 15:30 to 16:30 PM
Introduction: Definition of two-phase flow terms and its parameter (local and Temporal

Averaging), definitions of micro mini and conventional channels.

Lecture 2 – Flow Patterns: 16:45 to 17:45 PM
Two-phase flow patterns (adiabatic flows, in-tube condensation and evaporation, tube bundles, falling film evaporation and condensation).

Lecture 3 – Flow Pattern Prediction Methods: 18:00 to 19:00 PM
Flow pattern maps, mechanistic criteria for flow pattern transitions and flow pattern predictive methods in microchannels.

February 15 - Tuesday
Lecture 4 – Conservation Laws Applied to Two-Phase Flows: 15:30 to 16:30 PM
Conservation equations (mass, momentum and energy conservation) applied to two-phase flows.

Lecture 5 – Kinematic Models: 16:45 to 17:45 PM
Kinematic Models (homogeneous and drift flux), miscellaneous of void fraction models.

Lecture 6 – Pressure Drop in Two-Phase Flows: 18:00 to 19:00 PM
The concept of two-phase multipliers, flow patterns-based pressure drop prediction methods.
Tutorial 1: 19:15 to 20:15 PM
Evaluation of pressure drop, flow pattern and refrigerant inventory in a heater spreader based on evaporation (or condensation) of a natural refrigerant (isobutane). The evaluation is based on a one-dimensional model consisted of discreet elements.

February 16 - Wednesday
Lecture 7 - Boiling Fundamentals: 15:30 to 16:30 PM
Notions of nucleation (homogeneous and heterogeneous)

Lecture 8 – Pool Boiling: 16:45 to 17:45 PM
Pool boiling heat transfer mechanisms, pool boiling correlations.

Tutorial 2: 18:00 to 20:00 PM
Problem solving session with examples.

February 17 - Thursday
Lecture 10 – Flow Boiling: 15:30 to 16:30 PM
Flow Boiling inside channels, heat transfer mechanism, heat transfer asymptotic and flow pattern-based models for microchannels and conventional channel.

Lecture 11 - Critical Heat Flux: 16:45 to 17:45 PM
Critical heat flux and prediction methods for its evaluation under pool boiling and convective boiling conditions inside conventional and microchannels.

Tutorial 3: 18:00 to 19:00 PM
Continuation of tutorial 1 including the evaluation of the critical heat flux and the heat transfer coefficient for flow boiling along the microchannel.

February 18 - Friday
Lecture 9 – Fundamentals of Condensation: 15:30 to 16:30 PM
Introduction to Condensation: Dropwise and Filmwise condensation (Nusselt model).

Lecture 10 - **In-tube Condensation**: 16:45 to 17:45 PM
Condensation inside conventional and microchannels
Tutorial 4 18:00 to 19:00 PM
Continuation of tutorial 1 including the evaluation of the heat transfer coefficient for condensation along the microchannel.

Course Evaluation February 19 – Saturday

*** The course will be conducted in online mode.**

Who can attend?

- Students (BTech/BSc/MSc/MTech/PhD) and Faculties from reputed academic institutions and technical institutions.
- Engineers and researchers from manufacturing, service and government organizations including R&D laboratories.

e-Certificate:

Participation certificate will be given to each participant.

Registration Fees:

UG students: Rs. 5000
PG and Research scholars: Rs. 8000
Faculty members: Rs. 10000
Industry/R&D Organizations: Rs. 15000
Foreigners: USD 500

How to register?

Step 1: Send an email to the course coordinator Dr. Ritunesh Kumar (ritunesh@iiti.ac.in) expressing your interest. After the confirmation email only, the payment should be done.

Step 2: The payment can be made through NEFT Transfer to the following account details: Name of the Beneficiary: Registrar, Indian Institute of Technology Indore; Name of Bank: Canara Bank; Branch Code: IIT Indore Campus; Branch Beneficiary Account No.: 1476101027440; Bank IFS Code: CNRB0006223. Payment can be made through demand draft also.

Course Instructor

Prof. Gherhardt Ribatski
Mechanical Engineering Department
University of São Paulo (USP), Brazil

Brief Profile:

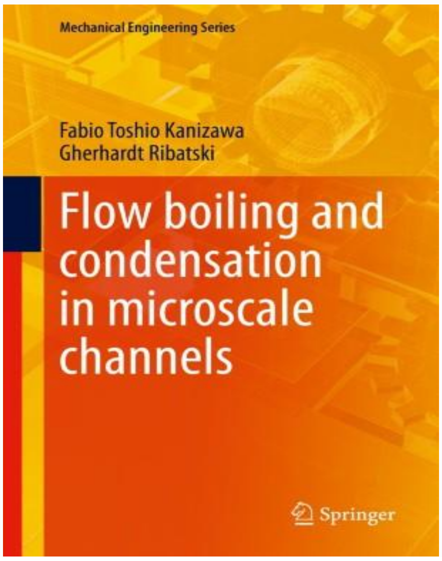
Dr. Gherhardt Ribatski is Full Professor of Multiphase Flow and Heat Transfer at the São Carlos School of Engineering, University of São Paulo (USP), Brazil. He received his BS, MSc. and Doctoral Degrees in Mechanical Engineering from the University of São Paulo. He held postdoctoral positions at the University of Illinois at Urbana– Champaign, Swiss Federal Institute of Technology in Lausanne (EPFL) and Universidade da Coruña. His research interests cover nanofluids, pool boiling, falling-film evaporation and condensation, two-phase flow, flow induced vibration, flow boiling and condensation for external and internal flows, heat transfer enhancement, heat exchangers, phase-change in microchannels, IR thermography and solar energy.

Prof. Ribatski is Brazilian Delegate to the Assembly for International Heat Transfer Conferences since 2017. Member of Assembly of World Conferences on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, Virtual Institute of Two-Phase Flow and Heat Transfer, Scientific Council of the International Centre for Heat and Mass Transfer (ICHMT), and corresponding member of The IceM NEWSLETTER / The Japanese Society for Multiphase Flow. Chair of the board of the "Nusselt-Reynolds Prize" awarded by the Assembly of World Conferences on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics. Member of IUTAM's (International Union of Theoretical and Applied Mechanics) Congress Committee). He is Subject Editor (Heat Transfer) of Applied Thermal Engineering, Associate Editor of the Experimental Thermal and Fluid Science and member of the Editorial board of International Journal of Multiphase Flow.

He was Director Secretary (2016-2017) and President of the Brazilian Society of Mechanical Sciences and Engineering (2018-2021). He has served as member of the CAPES (Coordination for the Improvement of Higher Education Personnel- Brazil) committee for evaluation of graduate programs in the areas of Mechanical, Mechatronics, Naval and Ocean, Aeronautical, Industrial and Petroleum Engineering. He is member of the area panel of Engineering of FAPESP (São Paulo Research Foundation – Brazil) and was Coordinator of the Graduate

Program of Mechanical Engineering at São Carlos School of Engineering (EESC) of University of São Paulo (USP) from 2014 to 2019.
He has presented 12 keynote lectures and taken part in the scientific committee of several International Conferences. Dr. Ribatski has over 100 refereed journal publications, 6 book chapters, 1 book and over 120 refereed papers in conferences.

The widely adopted text book by Prof. Gherhardt Ribatski on Flow boiling and condensation area:



Course Coordinator

Dr. Ritunesh Kumar is an Associate Professor in the Department of Mechanical Engineering, Indian Institute of Technology Indore. He received his PhD from Indian Institute of Technology, Delhi in the area of Refrigeration and Air-Conditioning. Prior to joining IIT Indore he had worked with Tata Consulting Engineers Limited, Vikhroli, Mumbai.
His research interest include heat transfer at micro-scale, desiccant cooling systemans and biofuels.

Contact Details

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