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ANNOUNCEMENT

TWO-PHASE FLOW AND HEAT TRANSFER

A short course to be held in Zurich, 18–22 March 1985
hosted by the
Swiss Federal Institute of Technology (ETH)

Two-Phase Flow and Heat Transfer

Zurich, March 18–22, 1985

LECTURERS

S. Banerjee, Professor of Chemical and Nuclear Engineering, University of California, Santa Barbara, California

G. Hetsroni, Professor of Mechanical Engineering, Technion, Haifa, Israel

G. F. Hewitt, Head of Engineering Sciences Division, AERE Harwell, UK

G. Yadigaroglu, Professor of Nuclear Engineering, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland

MONDAY, MARCH 18

1. **Introduction:** *G. F. Hewitt.* Philosophy and organization of the course. Introduction to two-phase flow and boiling heat transfer phenomena. Description of techniques.
2. **Basic Quantities and Thermodynamics of Phase Change:** *G. Hetsroni.* Definitions of local and averaged variables; the void fraction, phase and relative velocities, etc. Basic thermodynamic relationships and properties. Homogeneous nucleation.
3. **Conservation Equations:** *S. Banerjee.* Basic conservation equations for two-phase flow: averaging operators and their application. Simplified homogeneous, separated-flow, drift-flux, and multi-fluid formulations. Flow regime related models.
4. **Closure Relationships and Constitutive Equations:** *S. Banerjee.* Closure relationships for interfacial momentum and heat exchange. Interfacial area and interfacial-area transport equations. Distribution coefficients.

TUESDAY, MARCH 19

5. **Particles, Drops and Bubbles:** *G. Hetsroni.* Interactions between the continuous and the dispersed phases, motion of single dispersed-phase elements, multiple dispersed-phase element systems dispersed-phase separation processes.
6. **Pool and Convective Boiling:** *G. Yadigaroglu.* The mechanisms of nucleate boiling and forced-convection vaporization. Descriptions, models and recent correlations of pool and convection boiling regimes.
7. **Two-Phase Flow Regimes:** *G. F. Hewitt.* Importance of flow regimes, general description, classification, flow pattern maps, prediction of flow regime transitions.
8. **Computational Methods:** *S. Banerjee.* Numerical methods in two-phase-flow; limitations of numerical techiques, evaluation of the relative importance of various numerical schemes. Future developments in numerical modeling and associated computational methods.

WEDNESDAY, MARCH 20

9. **Burnout:** *G. F. Hewitt.* Mechanisms of burnout, parametric effects; correlation development for critical heat flux, prediction of burnout in annular flow.
10. **Non-Equilibrium and Critical Flows:** *S. Banerjee.* Types of departure from thermodynamic equilibrium in two-phase systems. Prediction of non-equilibrium and critical flows. Applications to reactor safety and chemical plant analysis.
11. **Pressure Drop and Void Fraction:** *G. F. Hewitt.* Mechanisms of pressure drop, theoretical predictions, empirical correlations. Void fraction models, correlations, and prediction.
12. **Wave Phenomena:** *S. Banerjee.* Types of interfacial waves and instability mechanisms: continuity waves, soliton waves, etc. Shock phenomena in two-phase flows, attenuation, propagation velocities; experimental results, analytical solutions, calculational techniques.

THURSDAY, MARCH 21

13. **Two-Phase Flow Equipment:** *G. F. Hewitt.* Two-phase flow equipment in the chemical, petrochemical, oil and gas, and other industries. Contacting equipment, etc.
14. **Post-Burnout Heat Transfer:** *G. Yadigaroglu.* Physical description and recent models of transition, inverted-annular and dispersed-flow film-boiling modes; correlations.
15. **Rewetting and Reflooding:** *G. Yadigaroglu.* The various types of rewetting phenomena, propagation of quench fronts. Two-phase flow and heat transfer during reflooding; experimental knowledge and modeling of phenomena.
16. **Steam Generators:** *G. Hetsroni.* Once-through and U-tube steam generators. Thermal-hydraulic design. Recent developments in generic corrosion, and mechanical problems. Design do minimize adverse effects.

FRIDAY, MARCH 22

17. **Mechanical Problems in Phase Change Equipment:** *G. Hetsroni.* Flow-induced vibrations in various single- and two-phase flow situations. Conventional and condensation induced water-hammer.
18. **Flow Instabilities:** *G. Yadigaroglu.* Classification of instabilities, fundamental mechanisms. The Ledinegg instability, flow distribution instabilities, density-wave oscillations, etc. Analytical tools for stability investigations, stability maps, steam generator stability.

COURSE DIRECTORS:

G. Hetsroni, G. Yadigaroglu

COURSE ADDRESS:

Please direct all correspondance and requests for additional information to

Prof. G. Yadigaroglu
ETH-Zentrum
CH-8092 Zurich, Switzerland
Telephone: (41-1) 256.4615

ORGANIZING COMMITTEE / THE LECTURERS:

Sanjoy Banerjee is Professor and Chairman of the Dept. of Chemical and Nuclear Engineering, Univ. of California - Santa Barbara. Previously, he has occupied in Canada the positions of Westinghouse Professor of Engineering Physics at McMaster Univ., and of Acting Director of Applied Science in the Whiteshell Nuclear Research Establishment. He was a founding member of the Canadian Advisory Committee on Nuclear Safety and serves as a consultant to governmental and industrial organizations in several countries. He is a member of several Editorial Boards, and has served as Chair of the ANS Thermalhydraulics Division.

Gad Hetsroni is Danciger Professor of Engineering at Technion - Israel Institute of Technological and Director of the S. Neaman Institute for Advanced Studies in Science and Technology. He has occupied positions at Westinghouse, EPRI, and Stanford Univ. in the US. He has also served as Director of the National Council for Research and Development in Israel, and as Dean of the Faculty of Mechanical Engineering at Technion. He has worked on many different aspects of two-phase flow and is the founder and Editor of the International Journal of Multiphase Flow and Editor of the Handbook of Multiphase Systems.

Geoffrey F. Hewitt is Head of the Engineering Sciences Division at the Harwell Laboratory in England. This Division is the centre for the Heat Transfer and Fluid Flow Service (HTFS). Dr. Hewitt has specialized principally in two-phase flow and heat transfer; has published widely in this area, including books on annular two-phase flow and measurement methods. He is Editor and Editorial Board Member for a number of international journals and a member of the Editorial Board of the Heat Exchanger Design Handbook.

George Yadigaroglu is Professor of Nuclear Engineering at the Swiss Federal Institute of Technology in Zurich (ETHZ). He was previously Professor of Nuclear Engineering at the Univ. of California - Berkeley, and from 1979 until 1982 he served as Head of the Nuclear Regulatory Service of the Greek Atomic Energy Commission. He has done research and has actively consulted for various organizations and national laboratories on a range of two-phase flow and heat transfer topics.

Two-phase flow and boiling heat transfer continue to focus the attention of researchers and to frustrate and challenge the engineer in the chemical, nuclear, oil-and-gas, cryogenic and other industries. New data and information, ideas and hypotheses, and facts and erroneous theories continue to be produced.

The short course described here is patterned after similar courses offered for a number of years at Stanford University in the USA. Its intent is to provide the practicing engineer or researcher with:

- A condensed and critical view of present knowledge, including areas of uncertainty, in two-phase flow and boiling heat transfer
- Sources of data and correlations
- Design and modelling philosophy and methods

The course features:

- A program of coordinated lectures by experts in the field (eighteen 1½-hr lectures)
- A complete set of lecture notes and copies of slides
- Movies to illustrate physical phenomena
- Limited enrollment

COURSE FEE

US $ 600 per registrant. Includes a non-refundable US $ 50 registration fee and the cost of all printed course lectures and materials. The fee does not include meals and hotel accommodations.

To secure registration please make bank transfer before February 15, 1985 to

Account «Seminar Fees»
Swiss Bank Corporation, Zurich
Account Number PO-413'021.1

The Organizing Committee reserves the right to cancel the course with full refund.

Registration form

Please mail before February 15, 1985 to course address.
Participants are urged to register as early as possible.

Name _____

Position and academic degrees _____

_____

Affiliation _____

Address _____

_____

_____

_____

Telephone _____ Telex _____

Please check appropriate boxes below:

Hotel Reservation (special rates available to participants):

☐ Please send information on hotel accommodations

☐ Will make my own reservations

Course Notes:

☐ to be mailed to address above before course

☐ will pick up during registration in Zurich

Signature _____ Date _____