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ANNOUNCEMENT

MULTIPHASE FLOW AND HEAT TRANSFER: BASES, MODELING AND APPLICATIONS

A 5-DAY WORKSHOP

Hosted by
Department of Chemical and Nuclear Engineering, The University of California, Santa Barbara, U.S.A.

20–24 September 1993

Course Directors
G. Hetsroni and S. Banerjee.

The Lecturers

Sanjoy Banerjee is Professor at the Department of Chemical and Nuclear Engineering, University of California—Santa Barbara. He is a member of several editorial boards, and has served as Chair of the American Nuclear Society Thermal Hydraulics Division.

Gad Hetsroni is Dançiger Professor of Engineering at Technion—Israel Institute of Technology. Presently, he is also a Visiting Professor, University of California—Santa Barbara. He has worked on many different aspects of two-phase flow and is the founder and Editor of the *Int. J. Multiphase Flow* and Editor of the *Handbook of Multiphase Systems*. He is a Fellow of the American Society of Mechanical Engineers.

Geoffrey F. Hewitt is Professor of Chemical Engineering at Imperial College London. He is Editor of a number of journals including *Experimental Heat Transfer*, *Transactions of the Institution of Chemical Engineers* and Associate Editor of the *Int. J. Multiphase Flow*. Professor Hewitt was the 1989/90 President of the Institution of Chemical Engineers and, in 1989, was elected a Fellow of the Royal Society.

Salomen Levy is the President of S. Levy Incorporated, a consulting firm to the power industry. Dr Levy is a member of several oversight and safety committees of nuclear power plants. He is a member of the National Academy of Engineering, a Fellow of the American Nuclear Society and American Society of Mechanical Engineers. He is a Director of IE Industries.

George Yadigaroglu is Professor of Nuclear Engineering at the Swiss Federal Institute of Technology in Zurich (ETHZ). He is also heading the Thermal-Hydraulics Laboratory at the Paul-Scherrer Institute (formerly EIR). He is a member of the editorial board of *Experimental Heat Transfer* and Associate Editor of the *Int. J. Multiphase Flow*. He is a Fellow of the American Society of Mechanical Engineers.

CONTENTS OF THE LECTURES

Monday, 20 September

1. **Introduction and Basics:** *G. Hetsroni.* Nature of multiphase flows. Definition of basic quantities. Basic concepts of control volume averaging. Homogeneous and mixture models.
2. **Basic Equations:** *S. Banerjee.* Averaging and derivation of conservation equations. Time and space dependent effects. Virtual mass. Multifluid models. Drift flux model. Requirements for closure relationships.
3. **Flow Regimes, Pressure Drop and Void Fraction:** *G. Hetsroni.* Description of flow regimes. Flow regime maps. Analytical bases for the flow regime transitions. Pressure drop and void fraction in various flow regimes.
4. **Phenomenological Modeling: Continuous Flow:** *G. F. Hewitt.* Bubble flow: drift flux correlations, void profile, turbulence, coalescence. Stratified flow: simple and more advanced models, turbulence. Annular flow: basic theory, entrainment and deposition, modeling, applications.

Tuesday, 21 September

5. **Phenomenological Modeling: Intermittent Flow:** *G. F. Hewitt.* Plug flow: bubble rise velocity, mechanisms, stability. Churn flow: mechanisms, interpretations, modeling. Slug flow: fluid behaviors in slugs, slug frequency and velocity.

6. **Closure Relationships:** *G. Yadigaroglu.* Interfacial area. Wall and interface friction. Relationships between void fraction and interfacial friction. Interfacial heat transfer. Empirical closure laws.
7. **Two-phase Heat Transfer:** *G. Hetsroni.* Boiling heat transfer: nucleate boiling, forced convection. Correlations and models. Dryout (critical) heat flux: mechanism and prediction.
8. **Post-dryout Heat Transfer and Rewetting:** *G. Yadigaroglu.* Description of physical phenomena: importance of departures from mechanical and thermal equilibrium. Dispersed flow film boiling: drop size spectrum and distributions. Various types of rewetting phenomena.

Wednesday, 22 September

9. **Numerical Methods:** *S. Banerjee.* Initial and boundary conditions. Method of characteristics. Finite difference methods. Stability. Explicit and implicit methods. Methods used in computer codes.
10. **Flow Limiting Phenomena:** *G. Yadigaroglu.* Critical two-phase flow: basic concepts, difficulties in calculating flow rate due to the nature of two-phase flow. Countercurrent-flow limitations: the flooding mechanisms, models, correlations; importance of geometry and subcooling.
11. **Multidimensional Modeling:** *S. Banerjee.* Basic multidimensional equations. Direct simulation. Large eddy simulation. Turbulence modeling: three-dimensional effects.
12. **Instabilities in two-phase flow:** *G. Yadigaroglu.* Instabilities of the liquid–gas interface. Modes of system instability: fundamentals, mechanisms. The Ledinegg instability, flow distribution instabilities, density wave oscillations etc. Analytical tools, stability maps, BWR stability.

Thursday, 23 September

13. **Computer Codes:** *G. F. Hewitt.* Generic approach in computer codes. Specific codes (RELAP, TRAC FLOW3D, PHOENICS, etc.). Achievements and limitations of codes. Future development and applications in nuclear systems.
14. **Two-phase Phenomena in Advanced Reactors:** *S. Levy.* Key phenomena associated with design of advanced water reactors. Special features arising from evolutions in design. Containment and passive safety aspects.
15. **Condensation Phenomena:** *G. F. Hewitt.* Modes of condensation. Interfacial resistance. Film condensation: gravity controlled and shear controlled. Spray condensation.
16. **Steam Generators:** *G. Hetsroni.* Nuclear steam generators. Design considerations. Operational problems: corrosion, vibration etc. Extension of lifetime. Alleviation of problems. New design concepts and replacement.

Friday, 24 September

17. **Severe Accidents:** *G. Yadigaroglu.* Severe accident scenario and phenomena. Vapour explosions. Debris-bed cooling etc.
18. **Space and Microgravity Applications:** *S. Banerjee.* Two-phase phenomena in microgravity environment: heat transfer and flow regimes. Space boiling and condensation systems.

REGISTRATION INFORMATION

Registration is requested by **1 September 1993**. To request space after this date call (805) 893-3412. No refunds will be granted after this date unless the workshop is cancelled. To secure registration, send registration form plus payment prior to **1 September**.

WORKSHOP FEES

Registration fees are $1200 (U.S.) and include lecture notes, copies of all slide notes, reception and workshop banquet. The lectures will be conducted at the Santa Barbara Inn. Because of space limitations, participants are urged to register well before the deadline.

HOTEL INFORMATION

Participants may stay at the Santa Barbara Inn at a special room rate of $109/night. Participants are strongly encouraged to take advantage of the low rate and the opportunity for enhanced contact with each other and the instructors. Please contact the hotel directly [*Tel*: (805) 966-2285 or *Fax*: (805) 966-6584] and mention the workshop.

FOR FURTHER INFORMATION CALL:

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