HEAT TRANSFER WITH PHASE CHANGE

Two-Phase Short Course, Stanford University, Department of Chemical Engineering, 15–19 August 1983

Two-phase flow and heat transfer continue to provide a focus for the attention of researchers and to frustrate and thwart the engineer, in the nuclear, chemical, and other industries. New data and information, ideas and hypotheses, facts and erroneous theories, continue to be produced.

The purpose of this course is to provide the practicing engineer with:

- An up-to-date condensed and critical view of the state of knowledge
- Highlights of salient points
- Sources of data and correlations
- Design philosophy and methods
- An outline of the outstanding areas of uncertainties

The course will consist of:

- A series of coordinated lectures by well known experts
- Lecture notes to be distributed prior to the course discussions
- Selected movies and slides to illustrate physical phenomena
- Excellent and convenient accommodations on the Stanford Campus
- Limited attendance

LECTURERS

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

P. Griffith Professor of Mechanical Engineering, MIT, Massachusetts

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

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

J. H. Lienhard Professor of Mechanical Engineering, University of Houston, Texas

C. L. Tien Professor of Mechanical Engineering, University of California, Berkeley, California

COURSE DIRECTOR

G. Hetsroni Visiting Scholar, Department of Chemical Engineering, Stanford University, Stanford, CA 94305, U.S.A.

G. G. Fuller Professor of Chemical Engineering, Stanford University, Stanford, CA 94305, U.S.A.

Monday, 15 August 1983

(1) *Introduction, flow regimes* (G. F. Hewitt). Objectives of course, types of phase change heat transfer, flow regimes in adiabatic systems, flow regimes in systems with evaporation and condensation.

(2) *Thermodynamics of phase change* (G. Hetsroni). Basic thermodynamic relationships, equations of state, thermophysical properties, interfacial tension, introduction to homogeneous nucleation.

(3) *Two phase flow models and numerical methods* (S. Banerjee). Local and averaged mass, momentum and energy balance equations, formulation techniques for systems with phase change, analytical and numerical solution procedures.

(4) *Non-equilibrium effects in phase change* (S. Banerjee). Forms of departure from thermodynamic equilibrium, mechanical non-equilibrium, general prediction methods for non-equilibrium systems, simplified models for prediction of heat transfer in non-equilibrium.

Tuesday, 16 August 1983

(5) *Nucleation and phase growth phenomena; I Bubbles* (P. Griffith). Homogeneous nucleation (theory and experimental), heterogeneous nucleation, bubble growth in liquid continuer and from solid surfaces, bubble departure.

(6) *Nucleation and phase growth phenomena: II Drops* (P. Griffith). Homogeneous nucleation of drops, nucleation phenomena in vapour expansion, heterogeneous nucleation at solid surfaces, drop growth in gaseous continuer and at solid surfaces, dropwise condensation.

(7) *Pool boiling* (J. H. Lienhard). Stages in pool boiling, the pool boiling curve, nucleate boiling, transition boiling, film boiling, theoretical models, empirical correlations.

(8) *Hydrodynamic instability effects in boiling* (J. H. Lienhard). Fundamentals of hydrodynamic instability, application of hydrodynamic instability theory to the prediction of critical heat flux in pool boiling, applications of theory in forced convective boiling.

Wednesday, 17 August 1983

(9) *Force convection boiling* (J. H. Lienhard). Regimes of force convective boiling, subcooled voids, two phase forced convective region, superposition correlations, film evaporation.

(10) *Burnout* (G. F. Hewitt). Mechanisms of burnout, parametric effects, correlation development for burnout heat flux, prediction of burnout in annular flow.

(11) *Post-burnout heat transfer* (P. Griffith). Post-burnout heat transfer regimes, forced convective film boiling, heat transfer to a droplet/vapour dispersion, effects of radiation.

(12) *Rewetting and reflooding* (S. Banerjee). Leidenforst phenomenon, propagation of rewetting fronts, reflooding phenomena, precursory cooling and its effect on rewetting, the effect of flow disturbances on rewetting.

Thursday, 18 August 1983

(13) *Filmwise condensation* (C. L. Tien). Laminar film condensation on vertical surfaces, turbulent film condensation, condensation on tube bundles, effect of vapour shear, condensation inside vertical and horizontal tubes.

(14) *Condensation equipment* (G. F. Hewitt). Classification of equipment types, air-cooled condensers, shell-and-tube condensers, brazed aluminium heat exchangers for condensation, direct contact condensation devices.

(15) *Phase change in porous media* (C. L. Tien). Fundamentals of transport phenomena in porous media, thermodynamic consideration, condensation and boiling in porous media, advanced models for flow with phase change.

(16) *Phase change in heat pipes* (C. L. Tien). General introduction to heat pipe technology, capillary transport phenomena, boiling and condensation in heat pipes, heat flux limiting phenomena in heat pipes, applications.

Friday, 19 August 1983

(17) *Boiling equipment* (G. Hetsroni). Classification of boiling equipment, boiling in cross flow, vapour generation systems, reboiler systems, generic problems in boiling equipment.

(18) *Mechanical and corrosion problems in phase change equipment* (G. Hetsroni). Tube vibration in two phase flow systems, prediction methods for tube vibration, corrosion problems in systems with phase change, fluid quality control, design to minimise corrosion and deposition.

Reservations

Please return by 1 July 1983

The course fee, including room and board, is $1,100 per registrant. Accommodations will be made on campus at one of Stanford's student residences (w/o private baths). Three meals per day will be provided. ☐

The course fee EXCLUSIVE of room and board is $800. I will be planning my own accommodations. ☐

Course Fee Includes Printed Lectures

Please make checks payable to Stanford University. Detach and mail to:

Department of Chemical Engineering
Stanford University
Stanford, CA 94305, U.S.A.

Name ____________________

Affiliation ____________________

Address ____________________

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Phone: ____________________