

Portonovo S. Ayyaswamy

Asa Whitney Professor of Dynamical Engineering
Department of Mechanical Engineering and Applied Mechanics
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PERSONAL

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EDUCATION

Ph.D. (1971) University of California, Los Angeles
Thesis Title: "Natural Convection Flows in Tilted Configurations"
Advisor: Professor Ivan Catton
M.E. (1967) Columbia University, New York
Thesis Title: "A Step by Step Design for Helical Tube Multi-Start Coil
Heat Transfer Equipment: Entering Tube Side Fluid in the
Super Critical Region or Otherwise"
Advisor: Professor Harold G. Elrod, Jr.
M.S. (1965) Columbia University, New York
B.E. (1962) University of Mysore

POSITIONS HELD

Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
1996-present Asa Whitney Professor of Dynamical Engineering
1987-present Professor
2004-2006 Chairman, Graduate Affairs
1990-1996
1984-1986 Chairman, Undergraduate Affairs
1980-1987 Associate Professor
1974-1980 Assistant Professor

Energy and Kinetics Department, University of California, Los Angeles
1972-1974 Post Doctoral Scholar
1973-1974 Supervisors: Professors Ivan Catton and Donald K. Edwards:
Topic: **Capillary flows in grooved surfaces.**
1972-1973 Supervisor: Professor David Okrent:
Topic: **Large scale safety of nuclear reactors.**

Institute of Geophysics and Planetary Physics, University of California, Los Angeles
1971-1972 Postdoctoral Fellow
Supervisor: Professor Friedrich H. Busse
Topic: **Bounding theories in turbulence.**

1969-1971 Post-Graduate Research Engineer
1968-1969 Teaching Associate
1967-1968 Research Assistant

The Lummus Company, Madison Avenue, New York
1966-1967 Heat Exchanger Engineer

School of Engineering and Applied Sciences, The City University of New York, New York
1964-1966 Instructor

Electronics Research Laboratories, Columbia University, New York, New York
1963-1964 Computer Assistant

Hydro-Electric Construction Project, Government of Mysore, Bangalore
1962-1963 Junior Engineer

HONORS/DISTINCTIONS

ASME 2007 Worcester Reed Warner Medal for outstanding contributions to the permanent literature of engineering	2007
Expert Consultant, Workshop on “Meeting the workforce needs for the National Vision for Space Exploration”, National Research Council of the National Academies Committee, Washington, DC	2006
Invited Member, Review of NASA Strategic Roadmaps: Space Station Panel, National Research Council of the National Academies Committee, Washington, DC	2005
ASME Heat Transfer Memorial Award in the Science Category for "many seminal contributions to such diverse fields of heat transfer as phase change, plasma, bio, and natural convection, in particular to transport processes with moving droplets and thermal design of advanced industrial equipment."	2001
Appointed Visiting Professor, Department of Mechanical Engineering, University of California, Berkeley, CA	2000
Council of Indian Organizations Award for Distinguished Contributions to Engineering Science	1999
“ Aerospace Professional of the Year ” award, Am. Inst. Aeronautics and Astronautics for “Outstanding contributions to the advancement of the arts and sciences of aeronautics and astronautics.”	1997
Appointed Asa Whitney Professor of Dynamical Engineering: “In recognition of his outstanding achievements in heat transfer research, excellence in teaching, and distinguished service to the University and his profession.”	1996

- Appointed United Nations Expert and Consultant for Engineering and Technology, UNIDO, Vienna, Austria 1991
- Elected **Fellow**, American Society of Mechanical Engineers for “significant contributions to Heat Transfer;” “His studies on droplet dynamics in the presence of phase change (condensation, evaporation, and combustion) have yielded new and important insights into mechanisms of drag and heat transfer.” 1990
- Outstanding Faculty Advisor Award:** “For dedication to quality education and development of professional awareness through student participation.” American Society of Mechanical Engineers 1979
- Lindback Award for Distinguished Teaching:** “For distinguished teaching, in recognition of outstanding service in stimulating and guiding the intellectual development of students at the University of Pennsylvania.” 1979
- Reid Warren Award for Distinguished Teaching:** “In recognition of outstanding service in stimulating and guiding the intellectual development of undergraduate students at the College of Engineering and Applied Science.” University of Pennsylvania, Philadelphia 1978

PATENTS

1. Bioactive, degradable composite for tissue engineering, U.S. Patent #6328990.
2. Hollow bone mineral-like calcium phosphate particles, U.S. Patent #6416774.

IMPORTANT KEYNOTE, INVITED LECTURES

- “The linear and non-linear stabilities of a Plasma-arc” University of Zurich, Zurich, Switzerland 1979
- Keynote address to Chinese Nuclear Society on “Heat and Mass Removal from Nuclear Reactor Containment by Spray Droplets,” China International Conference Center for Science and Technology, Beijing, People’s Republic of China 1985
- Invited Distinguished Participant and Keynote Speaker, Eighth National Heat and Mass Transfer Conference, Visakha Patnam, India. Invited by the Indian Society for Heat/Mass Transfer and the Ministry of Education, India. Address on “Heat and mass transfer with condensation” 1985
- “The theory of condensation on moving droplets” Cavendish Laboratory, University of Cambridge, England 1986
- “Hydrodynamics of condensation on a moving drop” The Royal Institute of Technology, Stockholm, Sweden 1986

- “Mathematics of direct-contact condensation on a moving drop” 1986
The Danish Center for Applied Mathematics & Mechanics,
The Technical University of Denmark, Lyngby, Denmark
- “Direct-Contact Phase Change Processes with Moving Liquid Droplets,” International 1994
Symposium/Workshop on Boiling, Condensation and Two-Phase Flow Heat Transfer,
Visakha Patnam, India
- Bio-Heat Transfer: “Effects of Micro-Wave Radiation on Biological Tissue Heating,” 1994
Bhabha Atomic Research Center, Bombay, India
- Am. Inst. Aeronautics and Astronautics award lecture: 1997
“Bone-cell growth in microgravity,” Philadelphia, PA
- Bio-Mass Transfer: “Bone-cell growth in microgravity--cell biology, fluid mechanics and 1997
mass transfer,” 14th National Heat and Mass Transfer Conference and the 3rd
ISHMT/ASME Joint Heat and Mass Transfer Conference, Kanpur, India
- "Interfacial motion of a molten layer subject to plasma heating" 1998
Chia-Shun Yih Memorial Symposium, 13th U.S. National Congress of Applied
Mechanics, Gainesville, FL
- “The culture of three-dimensional bone-like tissue under simulated microgravity 1999
conditions in NASA’s rotating-wall vessels: experimental and numerical studies.”
Engineering foundation conference on microgravity fluid physics and heat transfer
(Microgravity and fluid physics program of NASA), Oahu, Hawaii
- Bio-Mass Transfer Processes: “Composite microsphere: Effects of different filler 2001
materials on polymeric surface bioactivity.” Engineering Foundation Conference on
microgravity transport processes in fluid, thermal, biological and materials sciences II,
Banff, Alberta, Canada
- “Electric field effects on flames.” Fifth ISHMT ASME Heat and Mass Transfer 2002
Conference, Science City, Kolkata, India
- “Low energy plasma heat transfer as applied to microelectronic manufacturing.” 2002
International Symposium on Recent Trends in Heat and Mass Transfer, Indian
Institute of Technology, Guwahati, India
- "Three-dimensional bone-like tissue generation in rotating-wall bioreactors" 2003
The 6th Am. Soc. Mech. Engrs/Japanese Soc. Mech. Engrs. Thermal Engineering
Joint Conference, Hawaii Island, Hawaii
- “Oscillating Flow and Heat Transfer in Porous Media” 2004
NASA Glenn Research Center, Cleveland, Ohio
- “Loop Heat Pipe (LHP) for Spacecraft Thermal Control” 2004
NASA Glenn Research Center, Cleveland, Ohio
- Plenary Speaker, 2004 ASME Heat Transfer/Fluids Engineering Summer Conference, 2004
Charlotte, NC. “Surfactant Transport to an Intravascular Bubble”

Sir G.I. Taylor Memorial lecture in Fluid Mechanics, 53rd Congress of the Indian Society for Theoretical and Applied Mechanics, Hyderabad, India. “Motion Of A Finite-Sized Gas Bubble In A Blood Vessel: Non-Newtonian Effects.” 2008

MEMBERSHIP IN IMPORTANT PANELS, DELEGATION

Member, Review Panel, National Space Biomedical Research Institute, NASA, Washington, D.C. 2008, 2007

Invited Participant, NASA Workshop on Porous Media, NASA Glenn Research Center, Ohio 2004

Member, Requirements Definition Review Panel for Micro-Gravity Studies in Nucleate Boiling Heat Transfer, NASA Glenn, Ohio 2002

Member, NASA Bioreactor/Biosensor Research Review Panel, Washington D.C. 2002

Invited Participant, Workshop on research needs in space thermal systems and processes for human exploration of space, NASA Glenn, Ohio 2000

Member, Science Concept Review Panel for Micro-Gravity Experiments in Space, NASA, Lewis Research Center, Cleveland, Ohio 1998, 1990

Member, Review Panel for Micro-Gravity Studies in Heat Transfer and Fluid Mechanics, NASA, Washington, D.C 1997, 1993

Invited Panelist, NSF/DOE Workshop on Advanced Thermal Manufacturing and Materials Processing: Future Needs for Research, Leesburg, Virginia 1995

United Nations Expert on Micro-Electronics: Lectured and Conducted a workshop on “Thermal Design/Analysis/Optimization in Microelectronics”, Society for Applied Microwave Electronics Engineering and Research - Center for Electromagnetics, Madras, India 1992

Invited Panelist, NSF Workshop on “Thermal Engineering: Emerging Technologies and Critical Phenomena: Future needs for thermal engineering research,” Chicago, Illinois 1991

Invited Panelist, National Workshop on Mass, Momentum, and Energy Exchange in Combusting Sprays: Droplet Studies, Sandia National Laboratories, Livermore, California 1988

Member, Evaluation Panel for Engineering Initiation Awards, U.S. NSF 1987

Member, Delegation on Nuclear Reactor Safety to the People's Republic of China at the invitation of the Chinese Nuclear Society and the Chinese Association for Science and Technology (Delegation leader: Professor Richard T. Lahey, Jr.) 1985

IMPORTANT ADMINISTRATIVE RESPONSIBILITIES

Chairman, Graduate Affairs, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania	2004-2006, 1990-1996
Chairman, Faculty Appointments and Promotions Committee, School of Engineering and Applied Science, University of Pennsylvania	2001-02
Member, Consultative Committee for the Appointment of Endowed Chair Professorships, School of Engineering and Applied Science, University of Pennsylvania	2001-03
Chairman, Standing Committee on Academic Freedom and Responsibility, School of Engineering and Applied Science, University of Pennsylvania	1996-98
Member, Interschool Committee Concerning Teaching Evaluation (appointed by the Provost and Council of Deans), University of Pennsylvania	1992-95
Chairman, Committee on Graduate Mathematics Course Offerings, School of Engineering and Applied Science, University of Pennsylvania	1991-98
Member, Graduate Admissions Committee, Engineering Executive Program, University of Pennsylvania	1988-93
Secretary of the Faculty, School of Engineering and Applied Science, University of Pennsylvania	1987-88
Chairman, Undergraduate Affairs, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania	1984-1986
Chairman, Subcommittee of University-wide Undergraduate Financial Aid	1983-85
Member, Lindback Awards for Distinguished Faculty Selection Committee	1980, 1981, 1983
Elected Member, Search Committee for Samuel Landis Gabel Professorship, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania	1980
Member, Faculty Personnel Promotions Committee, School of Engineering and Applied Science, University of Pennsylvania	1979-80, 1988-89, 1991-92, 1994-97, 2001-03
Elected Faculty Representative, Search Committee for Dean of School of Engineering and Applied Science, University of Pennsylvania	1979, 1989, 1995, 1998
Member, Graduate Admissions Committee, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania	1979-89, 1996- 1998, 2001-
Chairman, Academic Performance Committee, School of Engineering and Applied Science	1979-80

Dean's Representative from School of Engineering, Committee on Undergraduate Admissions and Financial Aid, University of Pennsylvania 1979

Elected Member, Search Committee for Chairman, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania 1978, 1992, 1997

CONSULTING ACTIVITIES

Boeing Satellite Systems 2003-
Los Angeles, CA

Thermacore, Inc. 1999-2002
Lancaster, PA

Pathway Technology Inc. 1999-
Blue Bell, PA

Hughes Space and Communications 1996-2002
Los Angeles, CA

United Nations Industrial Development Organization July 1991-
Vienna, Austria

NASA, Glenn Research Center Jan 1990-
Cleveland, OH

IBM Corporation 1989-2001
Binghamton, NY

Battelle July 1984-87
P.O. Box 12297
Research Triangle Park, NC 27709

U.S. Army Chemical Research and Development Center May 1984-2000
Aberdeen Proving Ground, MD 21010

Combustion Unlimited Incorporated Jan 1978-90
Benjamin Fox Pavilion
Jenkintown, PA 19046

Pollution Control Division Feb 1976-99
National Air Oil Burner Co., Inc.
Philadelphia, PA 19134

JOURNAL EDITORSHIP

Editorial Panel member, Expert Review of Medical Devices, London, UK 2003 - Present

Associate Technical Editor, Journal of Heat Transfer, 1997-2000,
Transactions of the American Society of Mechanical Engineers 2001-2004

ARTICLE-REVIEWING ACTIVITIES

Reviewer for:

Journal of Fluid Mechanics
The Physics of Fluids
International Journal of Heat and Mass Transfer
ASME Journal of Heat Transfer
ASME Journal of Applied Mechanics
ASME Journal of Engineering for Power
ASME Journal of BioMechanical Engineering
ASME Journal of Fluids Engineering
AIAA Journal
Journal of Computational Physics
Numerical Heat Transfer
Combustion and Flame
Journal of the Franklin Institute
Solar Energy
The National Science Foundation, Washington, D.C.
The Department of Energy, Washington, D.C.
Transactions of the American Nuclear Society
Journal of Nuclear Engineering and Design
Journal of Computational Physics

Reviewer of Textbook Proposals and Manuscripts for:

McGraw-Hill Book Co.
MIT Press
Prentice-Hall, Inc.
West Publisher
Oxford University Press

LISTINGS

American Men and Women of Science

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Am. Soc. Mechanical Engineers (Elected Fellow in 1990)	1974-
Am. Nuclear Society	1977-
Radiation Research Society	1984-
Member, Sigma Xi	1991-
AIAA (Elected Associate Fellow)	1994-

SOCIETAL ACTIVITIES

Co-chairman, Symposium on Gas-Liquid and Phase-change flows at Macro-and Micro-scales, 2007 ASME International Mechanical Engineering Congress and Exposition, Seattle	2007
Co-chairman, Session on Targeted Drug Delivery and Treatment, Conference on Interdisciplinary Transport Phenomena, Bansko, Bulgaria	2007
Co-chairman, Session on Drops, Bubbles and Particles I, Conference on Interdisciplinary Transport Phenomena, Bansko, Bulgaria	2007
Member, Conference Scientific Committee, <u>Conference on Interdisciplinary Transport Phenomena V: Fluid, Thermal, Biological, Materials and Space Sciences</u> , Sponsored by Engineering Conferences International, Bansko, Bulgaria	2007
Session Organizer and Co-Chairman, Session on Biotransport I, <u>2005 Summer Bioengineering Conference</u> , Vail, Colorado	2005
Member, Conference Scientific Committee, <u>Conference on Interdisciplinary Transport Phenomena in Microgravity and Space Sciences IV</u> , Sponsored by Engineering Conferences International, Tomar, Portugal	2005
Co-Chairman, Session on Diffusion Process, <u>Conference on Interdisciplinary Transport Phenomena in Microgravity and Space Sciences IV</u> , Sponsored by Engineering Conferences International, Tomar, Portugal	2005
Co-Chairman, Session on Biotransport Phenomena I, <u>Conference on Interdisciplinary Transport Phenomena in Microgravity and Space Sciences IV</u> , Sponsored by Engineering Conferences International, Tomar, Portugal	2005
Co-Chairman, Session on Drops and Bubbles, <u>Conference on Interdisciplinary Transport Phenomena in Microgravity and Space Sciences IV</u> , Sponsored by Engineering Conferences International, Tomar, Portugal	2005
Co-Chairman, Session on Thermal Modeling in BioHeat Transfer Applications I, <u>2004 ASME International Mechanical Engineering Congress</u> , Anaheim, CA	2004
Co-Chairman and Session Organizer, Session on Modeling of Bioheat and Mass Transfer, <u>International Mechanical Engineering Congress and Exposition</u> , Washington, D.C.	2003
Chairman and Session Organizer, Session on Transport Phenomena in Biological Tissue, <u>The 6th ASME/JSME Thermal Engineering Joint Conference</u> , Hawaii	2003
Chairman and Session Organizer, Session on Cooling and Heating of Biological Tissues, <u>The 6th ASME/JSME Thermal Engineering Joint Conference</u> , Hawaii	2003
Member, Conference Scientific Committee, <u>Conference on Microgravity Transport Processes</u> , Sponsored by NASA and US NSF, Davos, Switzerland	2003

Co-Chairman, Session on Protein Crystal Growth, <u>Conference on Microgravity Transport Processes</u> , Sponsored by NASA and US NSF, Davos, Switzerland	2003
Session Organizer, Session on Biotransport Phenomena, <u>Conference on Microgravity Transport Processes</u> , Sponsored by NASA and US NSF, Davos, Switzerland	2003
Chairman, Session on Electromagnetic Phenomena, <u>Conference on Microgravity Transport Processes</u> , Sponsored by NASA and US NSF, Davos, Switzerland	2003
Member, Organizing Committee, <u>The 6th ASME/JSME Thermal Engineering Joint Conference</u> , Hawaii	2002-03
Chairman, Session on Transport Process during protein crystal growth under microgravity and earth gravity conditions, <u>International Symposium on Recent Trends in Heat and Mass Transfer</u> , Indian Institute of Technology, Guwahati, India	2002
Chairman and Session Organizer, Session on Modeling of microscale bioheat and mass transfer, <u>International Mechanical Engineering Congress and Exposition</u> , New Orleans, LA	2002
Co-Chairman and Session Organizer, Session on Bio-Transport Processes I, <u>Conference on Microgravity Transport Processes in Fluid, Thermal, Biological and Materials Sciences II</u> , Banff, Canada	2001
Co-Chairman and Session Organizer, Session on Bio Heat and Mass Transfer under Microgravity conditions, <u>International Mechanical Engineering Congress and Exposition</u> , Nashville, TN	1999
Co-Chairman and Session Organizer, Session on Bio Heat and Mass Transfer under Microgravity conditions, <u>International Mechanical Engineering Congress and Exposition</u> , Anaheim, CA	1998
Chairman, Session on Convection and Buoyancy Driven Flows III, <u>Am. Phys. Soc., Div. of Fluid Dynamics Meeting</u> , Philadelphia	1998
Co-Chairman and Session Organizer, Session on Assembly Technology-Processes, <u>The Pacific Rim/ASME Intl. Soc. Elec. & Phot. Pkg. Conf. & Exhibition</u> , Hawaii	1997
Co-Chairman and Session Organizer, Session on Bio Heat and Mass Transfer under Microgravity conditions, <u>International Mechanical Engineering Congress and Exposition</u> , Dallas, TX	1997
Chairman and Session Organizer, Session on Component Placement, <u>ASME International Electronics Packaging Conference</u> , Binghamton, NY	1993
Chairman and Session Organizer, Session on Microcomputer Codes/Applications in the Design and Analysis of Heat Exchangers, Pressure Vessels, and Piping, <u>The Winter Annual Meeting of the American Society of Mechanical Engineers</u> , Boston, Mass.	1987

Chairman, Session on Nuclear Heat Transfer, <u>Eighth National Heat and Mass Transfer Conference</u> , Visakha Patnam, India	1985
Dean's representative from University of Pennsylvania School of Engineering, <u>Behrend workshop on curriculum development for the Energy Environment Interface</u> , Sponsored by NSF, The Pennsylvania State University, Erie Campus	1981
Panelist, Session on Engineering Education, Conference of the National Society of Black Engineers, Philadelphia	1979
Co-Chairman, Session on Flow in Primary, Non-Rotating Passages in Turbomachines, Applied Mechanics Division, <u>The Winter Annual Meeting of the ASME</u> , New York	1979
Faculty Advisor, Society of Black Engineers, University of Pennsylvania Chapter	1978, 1979, 1980
Member, Solar Energy Division of the ASME (Inactive at present). Member, Heat Transfer Division of the ASME (National and Philadelphia sections). Member, Basic Engineering Section of the ASME (Philadelphia Section). Member, Nuclear Engineering Division of the ASME (National).	
Member, History and Heritage Committee of the ASM (Bi-Centennial Celebrations, Philadelphia Section)	1976-77
Faculty Advisor, Student Chapter of the ASME, School of Engineering and Applied Science, University of Pennsylvania	1975, 1976

MEMBERSHIP IN ASME COMMITTEES

Pressure Vessel and Piping Committee, Nuclear Engineering Division, American Society of Mechanical Engineers.

Committee on Heat and Mass Transfer in BioTechnology (K-17), Heat Transfer Division, American Society of Mechanical Engineers.

Heat Transfer Honors and Awards committee (K-3), American Society of Mechanical Engineers.

Max Jacob Award Committee, American Society of Mechanical Engineers and American Institute of Chemical Engineers.

INVITED COLLOQUIA

“Motion of a finite-sized gas bubble in a blood vessel: non-Newtonian effects,”
Indian Institute of Science, Bangalore, India

2008

- “Gas bubble motion in an arterial vessel: Casson fluid model”, 2007
Lehigh University, Bethlehem, Pennsylvania
- “Mass transfer to a bubble moving in an arterial vessel: Numerical Evaluations”, 2007
Villanova University, Villanova, Pennsylvania
- “Surfactant Transport to an Intravascular Bubble”, 2004
University of Southern California, Los Angeles, CA
- “Three dimensional bone-like tissue generation in NASA-designed rotating wall bioreactors”, 2003
University of Illinois at Urbana-Champaign, Illinois
- “Three dimensional bone-like tissue generation in NASA-designed rotating wall bioreactors”, 2003
University of Michigan, Dearborn, Michigan
- “Bone-cell growth in microgravity – cell biology, Fluid mechanics and Mass transfer”, 2001
University of Florida, Gainesville, Florida.
- “Electric field induced convection effects on flames”, 2001
University of Florida, Gainesville, Florida
- “Bone-cell growth in microgravity – Cell biology, Fluid mechanics, and Mass transfer”, 2000
University of California, Riverside, California
- “Electric field induced convection effects on flames”, 2000
University of California, Berkeley, California
- “Bone-cell growth in microgravity – Cell biology, Fluid mechanics, and Mass transfer”, 2000
University of California, Berkeley, California
- “Bone-cell growth in microgravity – Cell biology, Fluid mechanics, and Mass transfer”, 2000
University of Southern California, California
- “Bone-cell growth in microgravity – Cell biology, Fluid mechanics, and Mass transfer”, 2000
University of California, Irvine, California
- “Electric field induced convection effects on flames”, 2000
University of California, Irvine, California
- “Die Bonding by Oscillatory Squeezing”, 1997
The Pacific Rim/ASME Intl., Int. Soc. Elec. & Phot. Pkg. Conf. & Exhibition, Hawaii
- “Mixing, Evaporation and Combustion of Fuel Sprays at High Pressure and High Temperature”, 1995
Advanced Research Program, GE Aircraft Engines Division, Cincinnati, Ohio
- “Heat Clearance Properties of a Radiatively Heated Biological Tissue”, 1994
Bhabha Atomic Research Center, Bombay, India
- “Thermal Stresses in Microelectronic Components”, 1992
Society for Applied Microwave Electronics Engineering and Research, Madras, India

- “Thermal Design Analysis and Optimization in Microelectronics”, 1992
Center for Electronic Packaging technology and Ergonomic Design, SAMEER, Madras, India
- “A Five-lecture series on Advanced theories of Integral Equations with Applications in Radiative Heat Transfer and Interfacial Fluid Mechanics”, 1990
University of Bangalore, India: Department of Mathematics and Visveswaraya College of Engineering (Sponsored by the Division of Fluid Dynamics, University Grants Commission of India), Summer session
- “A Critical Look at BioHeat Transfer Equations”, 1989
University of Pennsylvania, Philadelphia, 1989.
- “Hydrodynamic Theory of Condensation on Moving Drops”, 1987
The Johns Hopkins University, Baltimore, Maryland
- “Hydrodynamics and Heat Transfer Associated with Condensation on a Moving Liquid Drop”, 1987
Rutgers University, Piscataway, New Jersey
- “Laminar Condensation on Moving Drops”, 1986
Indian Institute of Technology, Kanpur, India
- “Hydrodynamics and Heat Transfer Associated with Condensation on a Moving Liquid Drop”, 1986
Cavendish Laboratory, University of Cambridge, England
- “Theory of Condensation on Moving Liquid Drops”, 1986
Royal Institute of Technology, Stockholm, Sweden
- “Theory of Condensation on Moving Liquid Drops”, 1986
Laboratory of Applied Physics I, Technical University of Denmark, Lyngby, Denmark
- “Theory of Condensation on Moving Liquid Drops”, 1986
University of Lulea, Lulea, Sweden
- “Theory of Condensation on Moving Liquid Drops”, 1986
University of Arizona, Tucson, Arizona
- “Condensation Mechanisms Associated with Moving Liquid Drops”, 1986
University of Southern California, Los Angeles
- “Heat and Mass Transfer in Nuclear Reactor Containment by Droplet Sprays”, 1985
Chinese Nuclear Society, China International Conference Center for Science and Technology, Beijing, People's Republic of China
- “Effectiveness of Containment Spray Systems in Pressurized Water Reactors”, 1985
Sichuan Association for Science and Technology, Chengdu, People's Republic of China
- “Consideration of a Spectrum of Various Drop Sizes in Evaluating the Spray Efficiency in a Nuclear Reactor Containment”, 1985
Shanghai Association for Science and Technology, Shanghai, People's Republic of China

- “Natural Convection in Differentially Heated Enclosures”, 1985
Widener University, Swarthmore, Pennsylvania.
- Keynote Lecture on “Theory of Condensation on a Moving Drop”, 1985
Eighth National Heat and Mass Transfer Conference, Visakha Patnam, India
- “Thin Film Conductive Coatings for Surface Heating and Decontamination”, 1984
Chemical Systems Laboratory, U.S. Army Armament Research and Development,
Aberdeen Proving Grounds, Maryland
- “Condensation on a Translating Droplet; Heat Transfer, Mass Transfer, Fluid Mechanics”, 1982
Chemical Systems Laboratory, U.S. Army Armament Research and Development,
Aberdeen Proving Grounds, Maryland
- “Laminar Condensation on a Moving Drop”, 1980
Department of Mechanical Engineering, Columbia University, New York
- “Laminar Condensation on Moving Drop Which Has Internal Circulation” 1978
California Institute of Technology, Pasadena, California
- “Condensation Heat and Mass Transfer Associated with Translating Droplets”, 1978
Chemical, Nuclear and Thermal Engineering Department,
University of California, Los Angeles
- “Nonlinear Stability of Boussinesq Equations” 1973
Phi Mu Epsilon Society and the Department of Mathematics,
University of California, Los Angeles

RESEARCH EXPERIENCE AND DIRECTION

Areas of interest in early research included Wiped Film Hydrodynamics and Application to Desalination, Natural Convection in Enclosures, Thermal Stability - Linear and Energy Theories, Bounding Theories in Turbulence, and Large-Scale Safety of Nuclear Reactors (contributions to Rasmussen report).

Later research has been principally in the areas of:

- a) Convective Heat and Mass Transfer in the presence of a phase-change:
Forced Convection Effects on Condensation, Evaporation and Combustion. In particular, study of transport associated with moving liquid drops and sprays is emphasized. Melting and solidification of metals and alloys used in microelectronic manufacturing.
- b) Arc Plasma Heat Transfer and Processing Technology
Melting of metals and alloys by arc-discharges and subsequent solidification.
Effect of Forced Convection on Arc Plasma Heat Transfer, Arc stability, Interruption criteria, Thermal and Electrical characteristics of arc and glow discharges - analytical and experimental investigations. Applications in microelectronic packaging technology. Plasma Processing and etching.

- c) Convective Heat and Mass Transfer in Tissue subject to Microwave Heating:
Blood perfusion and Heat convection, Hyperthermia, Modeling of heat and mass transfer in tissue - analytical and experimental investigations.
- d) Microgravity Fluid Mechanics and Biotechnology Bone-Tissue Engineering:
Study of microcarriers in microgravity environment; fluid mechanics and mass transfer; Study of Osteoblasts, effect of shear on bone cells; development of novel biodegradable microcarriers for tissue engineering, study of apoptosis as a mechanism for bone loss in microgravity, apoptosis, osteoclastogenesis.
- e) Yield Stress Fluids and Interfacial Stability of Flowing Viscous Fluids:
Fundamental work on the effect of oscillation on Yield stress fluid flow, interfacial stability, Two and three fluid layer models, Wave generation on water surface by wind.
- f) Electro-Thermal-Compliant Actuation:
Design and microfabrication of MEMS based ETC wheels for Micro/Nano satellites; Design of ETC actuators for accelerometers
- g) Recirculating Aquaculture:
Design and scale-up studies of recirculating aquaculture production systems; Thermal regulation aspects, commercialization of recirculating aquaculture.
- h) Spacecraft thermal control using loop heat pipes:
Design of Loop heat pipes for spacecraft thermal control; capillary phenomena; experimental and numerical studies; studies aboard space shuttles.
- i) Activation of clotting and cell adhesion in gas embolism.
- j) Integrated Multiscale Modeling of Targeted Microcarrier Drug Delivery

Research has been primarily funded by NSF, NIH, EPRI, NASA, U.S. ACRDEC, and BFP.

MASTER'S, DOCTORAL AND POST-DOCTORAL RESEARCH SUPERVISION

1. L.J. Huang, Laminar Condensation on a Moving Drop: Effects of Transients, M.S. Thesis (1986).
2. S.G. Klemick, Heat Transfer in Tissue Subject to Microwave Heating, M. S. Thesis (1988).
3. T.R. Stauffer, Multi Foil Insulation Systems for Hypersonic Vehicles, M.S. Thesis (1992).
4. J. Weiner, Thermal Stress Analysis of Multilayered Materials of Finite Thickness, M.S. Thesis (1994).
5. A. Chau, Bubble motion in a Casson fluid flowing through a vessel, M.S. Thesis (In Progress).
6. J.N. Chung, Laminar Condensation Phenomenon Associated with a Moving Droplet, Ph.D. Thesis (1979).
(At present: Andrew H. Hines Jr./Florida Progress Eminent Scholar Chair Professor, U. of Florida, Gainesville.)
7. T. Sundararajan, Laminar Condensation Heat and Mass Transfer to a Drop Moving at Intermediate or High Reynolds Number, Ph.D Thesis (1983). (At present: Professor, Dept. of Mech. Eng., IIT, Madras, India)
8. J.M. Hogan, Wave Phenomena on the Interface Separating Fluids of Different Viscosities, Ph.D. Thesis (1984). (At present: Manager of Engineering, GE, Seton Center, PA)

9. G. Gogos, Evaporation and Combustion of a Moving Liquid Drop, Ph.D Thesis (1986).
(At present: Associate Professor, Dept. of Mech. Eng., Univ. of Nebraska, Lincoln, Nebraska)
10. J.W. Baish, Convective Heat Transport Due to Blood Perfusion in Volumetrically Heated Biological Tissue, Ph.D. Thesis (1986). (Joint Advisor: Dr. K.R. Foster, Bioengineering)
(Presidential Young Investigator Award Recipient) (At present: Professor, Dept. of Mech. Eng., Bucknell Univ., PA)
11. L.J. Huang, Fundamental Problems in Heat Transfer and Fluid Mechanics of Phase-Change Processes with Liquid Drops, Ph.D. Thesis (1989). (At present: Senior Engineer, R&D, GM, Lockport, NY)
12. M. Jog, Asymptotic and Numerical Studies of Plasma Arc Heat Transfer and Phase-Change Heat Transfer, Ph.D. Thesis (1993). (Engineering Initiation Award Recipient; NSF Career Award Recipient)
(At present: Associate Professor, Dept. of Mech., Ind., and Nucl. Eng., University of Cincinnati, OH)
13. K. Zwick, The Fluid Mechanics of Bonding With Yield Stress Epoxies, Ph.D. Thesis (1996).
(At Present: Research Engineer, Kimberly-Clark, Inc., WI)
14. W. Qin, Numerical and Experimental Studies of Heat Transfer Phenomena in Microelectronic Packaging, Ph.D. Thesis (1997). (At Present: Supervisor Engineer, Kulicke & Soffa Industries, PA)
15. S. Sripada, Fundamental Studies in Plasma-Arc and Phase-Change Heat Transfer, Ph.D. Thesis (1999).
(At Present: Applications Engineer, i2 Technologies, Irving, TX)
16. H. Gao. Numerical studies of microcarrier particle dynamics and associated mass transfer in rotating wall vessels, Ph.D. Thesis (2000). (At Present: Engineering Specialist, Kimberly-Clark, Inc., WI)
17. M. Parker, Modeling of Looped heat pipes with applications to spacecraft thermal control (2000)
(At Present: Thermal Engineering Specialist, Boeing Satellite Division, CA)
18. K. Mukundakrishnan, Fluid mechanics and mass transfer in rotating cylindrical vessels: A numerical and experimental study, Ph.D. Thesis (2005).
19. Josh Lampe, Interfacial characteristics of a gas bubble immersed in a surfactant and protein laden fluid: Experiments and Modeling, Ph.D. Thesis (2007) (Joint advisor: Prof. David Eckmann)
20. Dr. G.C. Das, Indian Institute of Plasma Physics, Bangalore, India, Research on the Thermal and Electrical Characteristics of Plasma Arcs (1976-77).
21. Dr. T. Sundararajan, University of Pennsylvania, Research in Hydrodynamics and Heat/Mass Transfer Associated with Condensation on Moving Spray Drops (1983-1985).
22. Dr. L.J. Huang, University of Pennsylvania, Research in Thermal and Resultant Stresses in Microelectronic Packaging (1989-1990).

23. Dr. M. Lavy, University of Cambridge, England, Research on Non-Equilibrium Wet Steam Flow in Turbine Cascades (1990-1991).
24. Dr. Q.Q. Qiu, University of Toronto, Canada, Research on the Use of Bioactive Glass Particles as Microcarriers in Microgravity Environment (supervision jointly with Professor P. Ducheyne), (1995-1999).
25. Dr. S. Radin, All-National Research Institute for Aircraft Materials, Russia, Research on Surface transformation of reactive glass in a microgravity environment (supervision jointly with Professor P. Ducheyne, 1998-2002)
26. Dr. J. Zhang, Northwestern University, Research in Fluid Mechanics/Mass Transfer associated with gas embolism, (2002-2005).
27. Dr. S. Quan, University of Massachusetts, Macromolecule Adsorption and Bubble Adhesion to Model Endothelial Surface, (2005-2007).
28. Dr. K. Mukundakrishnan, University of Pennsylvania, Numerical Studies of Intravascular Bubble Motion, (2005-2008).
29. Dr. A.J. Calderon, University of Michigan, Ann Arbor, MI, Fluid Mechanics and Mass transfer of Targeted Drug delivery, (2006-present).
30. Dr. T.N. Swaminathan, University of Pennsylvania, Numerical Studies of Intravascular Bubble Motion, (2008-present).
31. Dr. S. Dasgupta, Washington State University, Pullman, WA, Experimental and modeling studies of gas embolism, (2008-present).
32. Dr. U. Balakrishnan, Indian Institute of Technology, Madras, India, Numerical modeling of gas bubble/targeted drug delivery microcarrier motion in a blood vessel, (2009-present)
33. Dr. J. Liu, Johns Hopkins University, Baltimore, MD, Numerical modeling of targeted drug delivery microcarriers, (2009-present)

FUNDED RESEARCH ACTIVITIES

(Where a Principal Investigator is indicated, Ayyaswamy is a Co-Principal Investigator)

1. Grant Number: RO1 EB06818
Sponsor: NIH/NIBIB and NIGMS
Title: Targeted microcarrier design and optimization
Principal Investigator: D. M. Eckmann (School of Medicine, Univ. of Pennsylvania)
Award Amount: \$1,575,000
Period of Award: 2008-2012
2. Grant Number: N00014-08-1-0436
Sponsor: ONR
Title: Molecular Basis of Injury and Treatment of Arterial Gas Embolism
Principal Investigator: D. M. Eckmann (School of Medicine, Univ. of Pennsylvania)
Award Amount: \$1,006,274
Period of Award: 2008-2011

3. Grant Number: NNC05GA30G
Sponsor: NASA
Title: Macromolecule Adsorption and Bubble Adhesion to Model Endothelial Surface
Principal Investigator: D.M. Eckmann (School of Medicine, Univ. of Pennsylvania)
Award Amount: \$602,245
Period of Award: 2004-2006
4. Grant Number: RO1 HL67986-01A1
Sponsor: NIH
Title: Activation of clotting and cell adhesion in Response to gas embolism
Principal Investigator: D.M. Eckmann (School of Medicine, Univ. of Pennsylvania)
Award Amount: \$1,460,000
Period of Award: 2002-2007
5. Grant Number: NAG 9-1357
Sponsor: NASA
Title: Impact of microgravity on human osteoblast life history: Experimental investigation and Numerical study
Principal Investigator: Irving Shapiro (School of Dental Medicine, Univ. of Pennsylvania)
Award Amount: \$745,000
Period of Award: 2001-2004
6. Grant Number: 536689
Sponsor: Kulicke & Soffa Co., PA
Title: Design Improvements on wire bonding machinery
Award Amount: \$101,912
Period of Award: 9/1/00 - 8/31/01
7. Grant Number: 5-35816
Sponsor: NSF & Pathway Technologies, Inc.
Title: A feasibility study on Electro-thermal compliant wheel and a micro accelerometer
Principal Investigator: G. K. Ananthasuresh
Award Amount: \$106,000
Period of Award: 6/1/00 - 5/31/01
8. Grant Number: 5-08727
Sponsor: Thermacore, Inc., PA
Title: Transport Phenomena in wick structures
Award Amount: \$24,303
Period of Award: 6/1/00 - 5/31/01
9. Grant Number: NAG8-1483
Sponsor: NASA
Title: Surface Transformation of Reactive Glass in a Microgravity Environment
Principal Investigator: Paul Ducheyne
Award Amount: \$403,300
Period of Award: 2/1/98 - 1/31/02

10. Grant Number: 5-01963
Sponsor: Delaware River Port Authority
Title: Recirculating Aquaculture System
Principal Investigator: Leon Weiss
Award Amount: \$450,000 + \$350,000
Period of Award: 7/1/97 - 6/30/99, renewal to 6/30/01
11. Grant Number: KS-95
Sponsor: Kulicke and Soffa Industries, Inc.
Title: Die Attach Adhesive Characterization Study
Award Amount: \$35,263
Period of Award: 7/1/95-9/1/96
12. Grant Number: CTS-9421598 & REU
Sponsor: National Science Foundation
Title: Low energy arc heat transfer with applications in microelectronic packaging technology
Award Amount: \$259,931
Period of Award: 5/95 -4/97
13. Grant Number: NAG 9-817
Sponsor: NASA
Title: The use of bioactive glass particles as microcarriers in microgravity environment
Award Amount: \$730,000
Period of Award: 7/95- 6/99
14. Grant Number: DDM 90-005732 & REU
Sponsor: National Science Foundation
Title: Advances in Design of Automated Wire and Die Bonding Machinery in Microelectronic Manufacturing
Award Amount: \$274,250
Period of Award: 6/1/90 - 8/31/94
15. Grant Number: BFP #90S.5055R-01 and #89S.5055R-01
Sponsor: Benjamin Franklin Partnership/State of Pennsylvania
Title: Design of Automated Packaging Machinery in Microelectronic Manufacturing
Award Amount: \$60,000
Period of Award: 6/30/90- 8/31/93
16. Sponsor: Kulicke & Soffa Industries, Inc.
Title: Advances in Wire Bonding
Award Amount: \$53,000
Period of Award: 6/30/90 -8/31/94

17. Grant Number: 3-71747
Sponsor: University of Pennsylvania Research Foundation
Title: Numerical Simulation of Process Problems in the Design of Automated Machinery for Assembly of Semiconductor Integrated Circuit Chip
Award Amount: \$15,925
Period of Award: 1/7/92-12/31/92
18. Grant Number: 5-21201
Sponsor: IBM Corporation
Title: Analysis and Simulation of Thermal Transients and Resultant Stresses in Microelectronic Equipment
Award Amount: \$29,975
Period of Award: 7/1/90 - 6/30/91
19. Grant Number: DMC 87-09537 & REU
Sponsor: National Science Foundation
Title: Ball Formation Processes in Wire Bonding Apparatus
Award Amount: \$261,654
Period of Award: 6/1/88 - 5/31/90
20. Grant Number: BFP #07,510 RU
Sponsor: Benjamin Franklin Partnership/State of Pennsylvania
Title: Ball Formation Processes in Wire Bonding Apparatus
Award Amount: \$19,669
Period of Award: 9/1/88 - 8/31/89
21. Grant Number: BFP #06,500 NU
Sponsor: Benjamin Franklin Partnership/State of Pennsylvania
Title: Ball Formation Processes in Wire Bonding Apparatus
Award Amount: \$23,000
Period of Award: 9/1/87 - 8/31/88
22. Grant Number: DMC 85-13128 & REU
Sponsor: National Science Foundation
Title: Ball Formation Processes in Wire Bonding Apparatus
Award Amount: \$220,365
Period of Award: 9/1/85 - 1/30/88
23. Grant Number: 5-R01-CA-36624-03 Sub 01
Sponsor: National Institute of Health
Title: Dynamic Phantom Models for Hyperthermia Research
Award Amount: \$40,008
Period of Award: 6/1/85 - 5/31/86
24. Grant Number: 5-RO1-CA-36624-02 SUB 01
Sponsor: National Institute of Health
Title: Dynamic Tissue Models for Hyperthermia Research
Award Amount: \$105,830
Period of Award: 6/1/83 - 5/31/85

25. Grant Number: MEA82-17097
Sponsor: National Science Foundation
Title: Laminar Film Condensation on Drops Translating in Steam-Air Mixture
Award Amount: \$61,743
Period of Award: 7/1/83 - 12/31/84
26. Grant Number: MEA80-23861
Sponsor: National Science Foundation
Title: Laminar Film Condensation on a Droplet Translating in Steam-Air Mixture
Award Amount: \$60,770
Period of Award: 7/1/81 - 4/30/83
27. Grant Number: 5-RO1-CA-26046
Sponsor: National Institute of Health
Title: Microwave Dielectric Properties of Tumor and Normal Tissue
Principal Investigator: Kenneth Foster
Award Amount: \$53,516
Period of Award: 7/1/81 - 6/30/82
28. Grant Number: ENG78-25899
Sponsor: National Science Foundation
Title: Electrostatic Sheath Stability in Magnetohydrodynamic Flows
Principal Investigator: Ira M. Cohen
Award Amount: \$93,033
Period of Award: 4/1/79 - 9/30/81
29. Grant Number: ENG77-23137
Sponsor: National Science Foundation
Title: Laminar Film Condensation on a Spherical Droplet Translating in a Steam-air Mixture
Award Amount: \$80,147
Period of Award: 4/15/78 - 3/31/81
30. Grant Number: FAC. Grant & Award Project #0060
Sponsor: University of Pennsylvania Faculty Grants and Awards
Title: Turbulent Couette Motion
Award Amount: \$1,000
Period of Award: 7/1/76 - 6/30/77
31. Grant Number: RP-378-1
Sponsor: Electric Power Research Institute
Title: Arc Discharges
Principal Investigators: Ira M. Cohen/Alan Whitman
Award Amount: \$166,000
Period of Award: 12/1/74 - 6/30/77

FUNDED GRANTS FOR ACADEMIC ACTIVITIES

1. Grant Number: PO94B30032
Sponsor: U.S. Department of Education
Title: Patricia Roberts Harris Doctoral Fellowships
Co-Authors of Proposal: D. Graves, W. Shieh and M. Steedman
Award Amount: For MEAM Department: 2 Fellowships @ \$28,000 per year, per student, for a total of three years.
Period of Award: 1993-1998

2. Sponsor: National Science Foundation and Advanced Research Project Agency (NSF-ARPA)
Title: A Program for Manufacturing Management in Support of the Technology Reinvestment Program
Principal Investigators: G. Anandalingam and J. Adler
Co-Faculty Contributors: I.M. Cohen, N. Dorny, V. Kumar and W. Seider
Award Amount: \$600,000
Period of Award: 1994-1997

PENDING GRANT APPLICATIONS

1. Activation of clotting & cell adhesion : gas embolism
Principal Investigator: D.M. Eckmann (School of Medicine, Univ. of Pennsylvania)
Submitted to NIH
Funds requested: \$1,934,096
Period (expected): 2007-2012

2. Integrated Multiscale Modeling of Targeted Microcarrier Drug Delivery
Principal Investigator: R. Radhakrishnan
Submitted to NIH
Funds requested: \$1,796,219
Period (expected): 2007-2012

PUBLICATIONS

a). REVIEW ARTICLES BY INVITATION

- “Fluid Mechanics of Direct-Contact Transfer Processes with Moving Liquid Droplets” in **Encyclopedia of Fluid Mechanics** (Ed. N.P. Cheremisinoff) 1989
- “Combustion Dynamics of Moving Droplets” in **Encyclopedia of Environmental Control Technology**. (Ed. P.N. Cheremisinoff) 1989
- “Direct Contact Transfer Processes with Moving Liquid Droplets” in **Advances in Heat Transfer** (Eds. Cho, Hartnett and Irvine, Jr.) 1995
- “Mathematical Methods in Direct-Contact Transfer Studies with Droplets” in **Annual Review of Heat Transfer**, vol. VII (Ed. Chang-Lin Tien). 1996

“Low Energy Plasma Heat Transfer as Applied to Microelectronic Packaging” in **Annual Review of Heat Transfer**, vol. XII (Ed. Chang-Lin Tien, V. Prasad and F. Incropera). 2002

“Numerical models of blood flow effects in biological tissues” (with J.W. Baish and K. Mukundakrishnan), in **Advances in Numerical Heat Transfer 3**, Editors: W.J. Minkowycz and E.M. Sparrow, (In Press, 2008). 2008

b). EDITED BOOKS AND BOOK PUBLICATIONS

Advances in Design and Analysis in Pressure Vessel Technology

Co-Editors: H. Chung, D.W. Nicholson, and W.S. Woodward, ASME Press, New York (1987).

Transport Phenomena with Drops and Bubbles

Co-Authors: S.S. Sadhal and J.N. Chung, Springer-Verlag Publishers (1997).

(Monograph contains significant new and unpublished work on Interfacial Fluid Mechanics).

Introduction to Biofluid Mechanics

Chapter 17 in *Fluid Mechanics*, P.K. Kundu and I.M. Cohen, Academic Press, MA, (2007).

c). PUBLICATIONS IN REFEREED JOURNALS/BOOKS

(* : INVITED PAPER)

1. “Prediction of Momentum Transfer between Rotating Cylinders: The Narrow Gap Problem” (with I. Catton). *J. Appl. Mech., Trans. ASME*, 39, No. 1, 33-35 (1972).
2. “The Boundary-Layer Regime for Natural Convection in a Differentially Heated, Tilted, Rectangular Cavity” (with I. Catton). *J. Heat Transfer, Trans. ASME*, 95, No. 4, 543-545 (1973).
3. “Capillary Flow in Triangular Grooves” (with I. Catton and D.K. Edwards). *J. Appl. Mech., Trans. ASME*, 41, No. 2, 332-336 (1974).
4. “On the Stability of Plane Parallel Flow between Differentially Heated, Tilted Planes” *J. Appl. Mech., Trans. ASME*, 41, No. 3, 554-556 (1974).
5. “Natural Convection Flow in a Finite, Rectangular Slot Arbitrarily Oriented with Respect to the Gravity Vector” (with I. Catton and R.M. Clever). *Int. J. Heat Mass Transfer*, 17, 173-184 (1974).
6. “On the Stability of Electric Arc Discharges” (with A.M. Whitman and I.M. Cohen). *J. Appl. Phys., Am. Inst. Phys.*, 47, No. 11, 4827-4832 (1976).
7. “Reactor Containment Heat Removal by Passive Heat Sinks Following a LOCA” (with J.N. Chung and K.K. Niyogi). *Nuclear Technology, J. Am. Nuc. Soc.*, 33, No. 3, 243-247 (1977).
8. “The Effect of Internal Circulation on the Heat Transfer of a Nuclear Reactor Containment Spray Droplet” (with J.N. Chung). *Nuclear Technology, J. Am. Nuc. Soc.*, 35, No. 3, 603-610 (1977).

9. “Thermal and Electrical Characteristics of a Two-Dimensional Tanh-Conductivity Arc” (with G.C. Das and I.M. Cohen). *J. Appl. Phys., Am. Inst. Phys.*, 49, No. 1, 160-165 (1978).
10. “Laminar Condensation Heat and Mass Transfer in the Vicinity of the Forward Stagnation Point of a Spherical Droplet Translating in a Ternary Mixture: Numerical and Asymptotic Solutions” (with J.N. Chung). *Int. J. Heat Mass Transfer*, 21, 1309-1324 (1978).
11. “Effect of Plug Flow on the Stability of Two-Dimensional Arcs” (with I.M. Cohen and T. Sundararajan). *IEEE Trans. on Plasma Science, PS-8*, No. 4, 390-394 (1980).
12. “Laminar Condensation Heat and Mass Transfer to a Moving Drop” (with J.N. Chung). *AIChE J.*, 27, No. 3, 372-377 (1981).
13. “Material Removal Associated with Condensation on a Droplet in Motion” (with J.N. Chung). *Int. J. Multiphase Flow*, 7, No. 3, 329-342 (1981).
14. “Heat Transfer in Surface-Cooled Objects Subject to Microwave Heating” (with K. R. Foster, T. Sundararajan and K. Ramakrishna). *IEEE Trans. on Microwave Theory and Techniques, MTT-30*, No. 3, 1158-1166 (1982).
15. “Flow Past a Liquid Drop with a Large Non-uniform Radial Velocity” (with S.S. Sadhal). *J. Fluid Mech.*, 133, 65-81 (1983).
16. “Laminar Condensation on a Moving Drop. Part I. Singular Perturbation Technique” (with J.N. Chung and S.S. Sadhal). *J. Fluid Mech.*, 139, 105-130 (1984).
17. “Laminar Condensation on a Moving Drop. Part II. Numerical Solutions” (with J.N. Chung and S.S. Sadhal). *J. Fluid Mech.*, 139, 131-144 (1984).
18. “Hydrodynamics and Heat Transfer Associated with Condensation on a Moving Drop: Solutions for Intermediate Reynolds Numbers” (with T. Sundararajan). *J. Fluid Mech.*, 149, 33-58 (1984).
19. “Heat and Mass Transfer Associated with Condensation on a Moving Drop: Solutions for Intermediate Reynolds Numbers by a Boundary Layer Formulation” (with T. Sundararajan). *J. Heat Transfer, Trans. ASME*, 107, No. 2, 409-416 (1985).
20. “Linear Stability of a Viscous-Inviscid Interface” (with J.M. Hogan). *Physics of Fluids, A, Am. Inst. Phys.*, 28 (9), 2709-2715 (1985).
21. “Ball Formation Processes in Aluminum Bonding Wire” (with I.M. Cohen). *Solid State Technology*, 28, No. 12, 89-92 (1985).
22. “Numerical Evaluation of Heat and Mass Transfer to a Moving Liquid Drop Experiencing Condensation” (with T. Sundararajan). *Numerical Heat Transfer*, 8, No. 6, 689-706 (1985).
23. “Perfused Phantom Models of Microwave Irradiated Tissue” (with J.W. Baish and K.R. Foster). *J. BioMech. Eng., Trans. ASME*, 108, No. 3, 239-245 (1986).
24. “Small Scale Temperature Fluctuations in Perfused Tissue During Local Hyperthermia” (with J.W. Baish and K.R. Foster). *J. BioMech. Eng., Trans. ASME*, 108, No. 3, 246-250 (1986).

25. “Thin-Flame Theory for the Combustion of a Moving Liquid Drop: Effects Due to Variable Density” (with G. Gogos, S.S. Sadhal and T. Sundararajan). *J. Fluid Mech.*, 171, 121-144 (1986).
26. “Heat Transport Mechanisms in Vascular Tissues: A Model Comparison” (with J.W. Baish and K.R. Foster). *J. BioMech. Eng., Trans. ASME*, 108, No. 4, 324-331 (1986).
27. “Heat and Mass Transfer Associated With a Spray drop Experiencing Condensation: A Fully Transient Analysis” (with L.J. Huang). *Int. J. Heat Mass Transfer*, 30, No. 5, 881-891 (1987).
28. “Heat Transfer of a Nuclear Reactor Containment Spray Drop” (with L.J. Huang). *J. Nucl. Eng. and Design*, 101, 137-148 (1987).
29. “The Drag Coefficients Associated with a Moving Liquid Drop Experiencing Condensation” (with L.J. Huang). *J. Heat Transfer, Trans. ASME*, 109, No. 4, 1003-1006 (1987).
30. “A Model for the Evaporation of a Slowly Moving Liquid Droplet” (with G. Gogos). *Combustion and Flame*, 74, 111-129 (1988).
31. “Two-Dimensional Analysis of Electrical Breakdown in a Non-Uniform Gap between a Wire and a Plane” (with K. Ramakrishna and I.M. Cohen). *J. Appl. Phys., Am. Inst. Phys.*, 65 (1), 41-50 (1989).
32. “An Experimental Study of Ball Formation Processes with Aluminum and Copper” (with I. M. Cohen and K. Ramakrishna). *Experimental and Thermal Fluid Science*, 2, 51-64 (1989).
33. * “Combustion Dynamics of Moving Droplets” *Encyclopedia of Environmental Control Technology*, 1, 479-532 (1989).
34. “Temperature Response of a Heated Cylinder Subject to Side Cooling - Asymptotic and Numerical Solutions” (with K. Ramakrishna and I.M. Cohen). *J. Heat Transfer, Trans. ASME*, 111, No. 3, 592-597 (1989).
35. “An Analysis of Shrinkage Porosity in Aluminum Ball Bonding Process” (with L.J. Huang, K. Ramakrishna and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 111, No. 3, 199-206 (1989).
36. * “Fluid Mechanics of Direct-Contact Transfer Processes with Moving Liquid Droplets” *Encyclopedia of Fluid Mechanics*, 8, 535-587 (1989).
37. “Evaporation of a Moving Liquid Droplet: Solutions for Intermediate Reynolds Numbers” (with L.J. Huang). *Int. Comm. Heat Mass Transfer*, 17, No. 1, 27-28 (1990).
38. “Ball Formation in Wire Bonding: Part I, Upscaled Experimental Study” (with L.J. Huang, K.M. Yu, S. Powell, and I. M. Cohen). *Int. J. Hybrid Microelectronics*, 13 (1), 1-5 (1990).
39. “Ball Formation in Wire Bonding: Part II, Real Scale Experimental Study” (with S.C. Chang, I. M. Cohen, and L.J. Huang). *Int. J. Hybrid Microelectronics*, 13 (2), 29-34 (1990).
40. “Effect of Internal Circulation on the Transport to a Moving Drop” (with S.S. Sadhal and L.J. Huang). *Int. Comm. Heat Mass Transfer*, 17, No. 6, 689-701 (1990).
41. “Effect of Insoluble Surfactants in Condensation on a Moving Drop” (with L.J. Huang). *J. Heat Transfer, Trans. ASME*, 113, No. 1, 232-236 (1991).

42. “A Note on the Interface Condition in Phase Change Problems” (with L.J. Huang and I. M. Cohen). *J. Heat Transfer, Trans. ASME*, 113, No. 1, 244-247 (1991).
43. “Effect of Polarity on Heat Transfer in the Ball Formation Process” (with L.J. Huang, M.A. Jog and I. M. Cohen). *J. Electronic Packaging, Trans. ASME*, 113, No. 1, 33-39 (1991).
44. “Breakdown of a Wire-to-Plane Discharge: Transient Effects” (with M.A. Jog and I.M. Cohen). *Physics of Fluids, B, Am. Inst. Phys.*, 3 (12), 3532-3536 (1991).
45. “Electrode Heating in a Wire-to-Plane Arc” (with M.A. Jog and I.M. Cohen). *Physics of Fluids, B, Am. Inst. Phys.*, 4 (2), 465-472 (1992).
46. “Numerical Methods for Two-Dimensional Analysis of Electrical Breakdown in a Non-uniform Gap” (with K. Ramakrishna and I. M. Cohen). *J. Comp. Phys.*, 104, 173-184 (1993).
47. “Analysis and Simulation of Thermal Transients and Resultant Stresses and Strains in TAB Packaging” (with M.A. Jog and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 115, 34-38 (1993).
48. “Effect of Negative Ions on Electrical Breakdown in a Non-Uniform Air Gap” (with K. Ramakrishna and I.M. Cohen). *Phys. Plasmas, Am. Inst. Phys.*, 1 (5), 1349-1358 (1994).
49. “Heat Transfer in Wire Bonding Process” (with M.A. Jog and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 116, 44-48 (1994).
50. “Fixed Wand Electronic Flame Off for Ball Formation in the Wire Bonding Process - Side Discharge” (with W. Qin and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 116, 212-219 (1994).
51. “Melting and Solidification of Thin Wires: A Class of Phase-Change Problems with a Mobile Interface, Part I: Analysis” (with L.J. Huang and I.M. Cohen). *Int. J. Heat Mass Transfer*, 38, No. 9, 1637-1645 (1995).
52. “Melting and Solidification of Thin Wires: A Class of Phase-Change Problems with a Mobile Interface, Part II: Experimental Confirmation” (with L.J. Huang and I.M. Cohen). *Int. J. Heat Mass Transfer*, 38, No. 9, 1647-1659 (1995).
53. “Jet-Flow Scavenging of a Curing Oven, Part I: Flow Visualization” (with K.J. Zwick and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 117, 215-219 (1995).
54. * “Direct Contact Transfer Processes with Moving Liquid Droplets” *Advances in Heat Transfer*, 26, 1-104 (1995).
55. “Jet-Flow Scavenging of a Curing Oven, Part II: Numerical Simulation” (with K.J. Zwick and I.M. Cohen). *J. Electronic Packaging, Trans. ASME*, 117, 220-224 (1995).
56. “Evaporation and Combustion of a Slowly Moving Liquid Fuel Droplet: Higher Order Theory” (with M.A. Jog and I.M. Cohen). *J. Fluid Mech.*, 307, 135-165 (1996).
57. * “Mathematical Methods in Direct-Contact Transfer Studies with Droplets” *Annual Review of Heat Transfer*, VII, 245-331, (1996).

58. “Variational Analysis of the Squeezing Flow of a Yield Stress Fluid” (with K. Zwick and I.M. Cohen). *J. Non-Newtonian Fluid Mechanics* 63, 179-199, (1996).
59. “Condensation on a Spray of Water Drops: A Cell Model Study, Part I: Flow Description” (with S. Sripada and L.J. Huang). *Int. J. Heat and Mass Transfer* 39, No. 18, 3781-3790, (1996).
60. “Condensation on a Spray of Water Drops: A Cell Model Study, Part II: Transport Quantities” (with L.J. Huang and S. Sripada). *Int. J. Heat and Mass Transfer* 39, No. 18, 3791-3797, (1996).
61. “Influence of Elasto-Plastic Behavior of Epoxy on Stresses and Strains in TAB Packaging” (with M.A.Jog and I.M. Cohen). *Int. J. Microcircuits & Electronic Packaging*, 19, No. 3, 308-315, (1996).
62. “Numerical Evaluation of Heat Clearance Properties of a Radiatively Heated Biological Tissue” (with S.G. Klemick and M.A. Jog). *Numerical Heat Transfer - Part A*, 31, No. 5, 451-467, (1997).
63. “Oscillatory Enhancement of the Squeezing Flow of Yield Stress Fluids: A Novel Experimental Result” (with K. Zwick and I.M. Cohen). *J. Fluid Mech.*, 339, 77-87, (1997).
64. “Surface Modified Bioactive Glass Particles as Microcarriers in a Microgravity Environment” (with P. Ducheyne, T. Livingston, I. Shapiro, H. Gao, and S. Radin) *Tissue Engineering*, 3, No. 3, 219-229, (1997).
65. “Three-Dimensional Bone Marrow Stromal Cell Culture on Microcarriers in a Rotating Wall Vessel” (with Q. Qiu, P. Ducheyne, and H. Gao) *Tissue Engineering*, 4, No. 1, 19-35, (1998).
66. “The Dynamics of a Microcarrier Particle in a Rotating Wall Vessel” (with H. Gao and P. Ducheyne) *Microgravity Science and Technology*, X/3, 154-165, (1997).
67. *Interfacial Motion of a Molten Layer Subject to Plasma Heating” (with S. Sripada and I.M. Cohen) *Fluid Dynamics at Interfaces*, Ed: W. Shyy, 320-338, Cambridge University Press (1998).
68. “Weakly Ionized Plasma Arc Heat Transfer Between Geometrically Dissimilar Electrodes” (with S. Sripada and I.M. Cohen). *J. Heat Transfer, Trans. ASME*, 120, No. 4, 939-942 (1998).
69. "Fabrication, characterization and evaluation of hollow bioceramic microspheres used as microcarriers for 3-D bone tissue formation in rotating bioreactors" (with Q. Qiu and P. Ducheyne) *Biomaterials*, 20, 989-1001 (1999).
70. "Heat affected zone in the wire electrode during electronic flame off in bonding" (with S. Sripada, I.M. Cohen, L. Medalla and B.J. Mulada). *Int. J. Microcircuits & Electronic Packaging*, 22, 203-211 (1999).
71. "The culture of three-dimensional bone-like tissue under simulated microgravity conditions in NASA's rotating-wall vessels: experimental and numerical studies" *Microgravity Fluid Physics and Heat Transfer*, Ed: V. Dhir, 183-196, begell house, Inc. (1999).
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