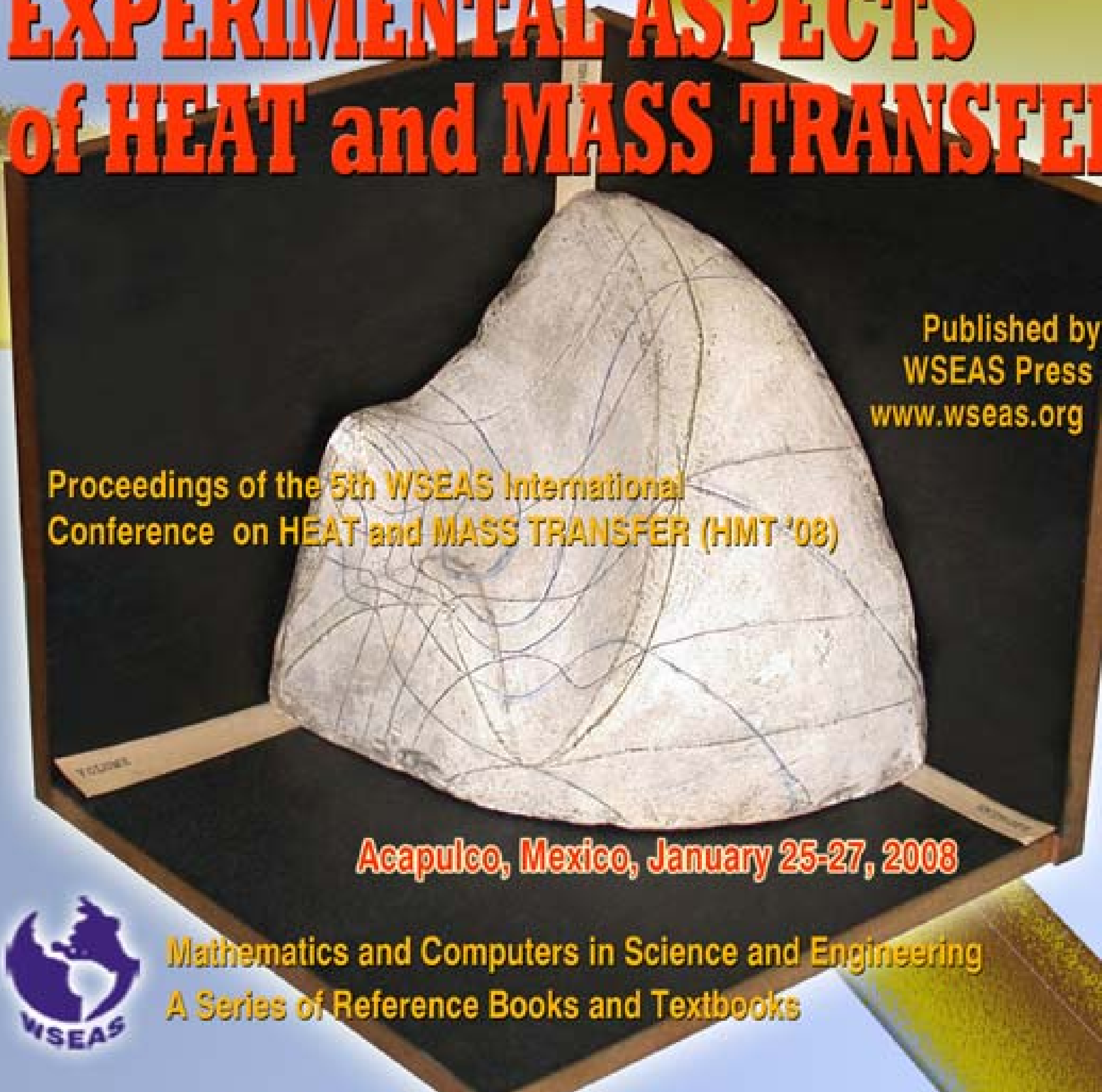
Editors: Prof. Jurij Krope Slovenia, Prof. Siavash H. Sohrab, USA
Prof. Dr.-Ing. F.-K. Benra, Germany

THEORETICAL and EXPERIMENTAL ASPECTS of HEAT and MASS TRANSFER



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Acapulco, Mexico, January 25-27, 2008

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Preface

This book contains proceedings of the 5th WSEAS International Conference on Conference on Heat and Mass Transfer (HMT'08) which was held in Acapulco, Mexico, January 25-27, 2008 The WSEAS Heat and Mass Transfer (HMT'08) Conference was held in Corfu, Greece, August 2004 and in Udine, Italy, January 2005 in Miami, Florida, USA, January 2006. It was also held in Gold Coast, Queensland, Australia, January 2007 and this year in Acapulco, Mexico. The Society (WSEAS) has also organized many other separate or joint conferences on Fluid Dynamics, Aerodynamics, Heat and Mass Transfer, Environmental Engineering, Numerical Mathematics etc.... The relevant titles could be retrieved from the web site: www.worldses.org/history.htm

The 5th WSEAS International Conference on Heat and Mass Transfer (HMT'08) aims to disseminate the latest research and applications in the afore mentioned fields. The friendliness and openness of the WSEAS conferences, adds to their ability to grow by constantly attracting young researchers. The WSEAS Conferences attract a large number of well-established and leading researchers in various areas of Science and Engineering as you can see from **http://www.wseas.org/reports** . Your feedback encourages the society to go ahead as you can see in **http://www.worldses.org/feedback.htm**

The contents of this Book are also published in the CD-ROM Proceedings of the Conference. Both will be sent to the WSEAS collaborating indices after the conference: **www.worldses.org/indexes**

In addition, papers of this book are permanently available to all the scientific community via the WSEAS E-Library.

Expanded and enhanced versions of papers published in these conference proceedings are also going to be considered for possible publication in one of the WSEAS journals that participate in the major International Scientific Indices (Elsevier, Scopus, EI, Compendex, INSPEC, CSA .... see: www.worldses.org/indexes) these papers must be of high-quality (break-through work) and a new round of a very strict review will follow. (No additional fee will be required for the publication of the extended version in a journal).

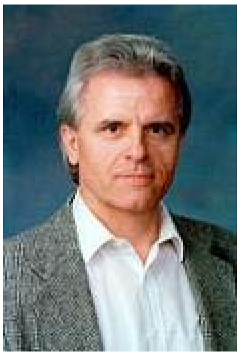
We cordially thank all the people of WSEAS for their efforts to maintain the high scientific level of conferences, proceedings and journals.

The Editors

Plenary Lecture I

Uniqueness and Universality of Heat Transfer:

Challenges and Opportunities for Improving Heat Transfer Processes - The Quest and Nature of Energy, Heat and Entropy



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Abstract: This presentation focuses on philosophical and practical aspects of energy, heat and entropy, with emphasis on reversibility and irreversibility, and a goal to establish the concept of ideal “reversible heat transfer,” regardless that heat transfer is a typical irreversible process. Heat transfer, like any other energy transfer, may be achieved from any-to-any temperature level, and in limit be reversible, if temperature of an intermediary cyclic substance is adjusted as needed, using isentropic compression and expansion. The reversible heat transfer limits are the most efficient and demonstrate limiting potentials for practical heat transfer processes. The heat transfer and thermal energy are unique and universal manifestation of all natural and artificial (man-made) processes, and thus are vital for more efficient cooling and heating in new and critical applications, including energy production and utilization, environmental control and cleanup, and bio-medical applications. Heat transfer is known as typical spontaneous irreversible process where all organized (structural) energies are disorganized or dissipated as thermal energy with irreversible loss of energy potential (from high to low temperature) and overall entropy increase. However, since reversible adiabatic expansion and compression change thermal-potential (temperature) without heat transfer, it makes possible to have reversible heat transfer from one thermal potential to either lower or higher, using reversible refrigeration or combined dual, powerand- heat-pump cycles, respectively, with overall increase in efficiency.

Brief Biography of the Speaker: Professor Kostic's teaching and research interests are in Thermodynamics (a science of energy, the Mother of All Sciences), Fluid Mechanics, Heat Transfer and related fluid-thermal-energy sciences; with emphases on physical comprehension and creative design, experimental methods with computerized data acquisition, and CFD simulation; including nanotechnology and development of new-hybrid, POLY-nanofluids with enhanced properties, as well as design, analysis and optimization of fluids-thermal-energy components and systems in power-conversion, utilizations, manufacturing and material processing. Dr. Kostic came to Northern Illinois University from the University of Illinois at Chicago, where he supervised and conducted a two-year research program in heat transfer and viscoelastic fluid flows, after working for some time in industry.*"Kostic's unique synergy of philosophical, theoretical, computational and experimental approach, results in open mind, intense curiosity and sharp focus for identifying and analyzing natural and engineering phenomena with high motivation for problem identification, troubleshooting and solving.* Kostic received his B.S. degree with the University of Belgrade Award as the best graduated student in 1975. Then he worked as a researcher in thermal engineering and combustion at The Vinca Institute for Nuclear Sciences, which then hosted the headquarters of the International Center for Heat and Mass Transfer, and later taught at the University of Belgrade in ex-Yugoslavia (*). He came to the University of Illinois at Chicago in 1981 as a Fulbright grantee, where he received his Ph.D. in mechanical engineering in 1984. Subsequently, Dr. Kostic worked several years in industry. In addition, he spent three summers as an exchange visitor in England, West Germany, and the former Soviet Union.Dr. Kostic has received recognized professional fellowships and awards, including multiple citations in Marquis' "Who's Who in the World" and "Who's Who in Science and Engineering."; the Fulbright Grant; NASA Faculty Fellowship; Sabbatical Semester at Fermilab as a Guest Scientist; and the summer Faculty Research Participation Program at Argonne National Laboratory. He is a frequent reviewer of professional works and books in Thermodynamics and Experimental Methods. Dr. Kostic is a licensed professional engineer (PE) in Illinois and a member of the ASME, ASEE, and AIP's Society of Rheology. He has a number of publications in refereed journals, including invited state-of-the-art chapters in the Academic Press series Advances in Heat Transfer, Volume 19, and "Viscosity" in CRC Press' Measurement, Instrumentation and Sensors Handbook; as well as invited reference articles: Work, Power, and Energy in Academic Press/Elsevier's Encyclopedia of Energy; Extrusion Die Design in Dekker's Encyclopedia of Chemical Processing; and Energy: Global and Historical Background and Physics of Energy in Taylor & Francis/CRC Press Encyclopedia of Energy Engineering and Technology. Professor Kostic is a member of the Graduate Faculty at Northern Illinois University.

Plenary Lecture II

Hyperbolic Conservation Laws: Theory and Numerical Simulations of Shock Reflection

Katarina Jegdic
Computer and Mathematical Sciences
University of Houston - Downtown
USA

Abstract: The first part of this talk is a brief introduction to the systems of partial differential equations known as conservation laws. We will discuss the physical background of these systems and show several applications. Notions of weak solutions and entropy conditions will be outlined. The second part of the talk is on analysis of two-dimensional Riemann problems for systems of conservation laws with applications to shock reflection. When written in self-similar coordinates, these problems lead to free boundary problems for the reflected shock and a subsonic state behind the shock. We will present our recent results (joint work with Barbara Lee Keyfitz and Suncica Canic) on analysis of these problems for the isentropic gas dynamics equations using the theory of second order elliptic equations with mixed boundary conditions and fixed point theory. The talk will conclude with numerical solutions to several Riemann problems for the full gas dynamics equations resulting in weak and strong regular reflection.

Brief Biography of the Speaker: Katarina Jegdic received B. Sc. degree in Mathematics from the University of Novi Sad, Serbia, in 1997. She obtained M.S. degree and Ph.D. degree in Mathematics from the University of Illinois at Urbana-Champaign, USA, in 2000 and 2004, respectively, after which she held a postdoctoral position at the University of Houston, USA. She is an assistant professor at the University of Houston - Downtown since fall of 2006. Her research interests are in mathematical and numerical analysis of systems of conservation laws with applications to shock reflection and petroleum engineering.

Plenary Lecture III

Nonlinear Convective Flow in Rotating Mushy Layers

Professor Daniel N. Riahi
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Abstract: We consider the problem of nonlinear convective flow in a horizontal mushy layer with deformable interface and rotating about a vertical axis. Under a near –eutectic approximation and the limit large far-field temperature, we examine the presence of the external constraint of rotation on reducing or enhancing the tendency for the chimney formation within the mushy layer. The chimneys produce undesirable freckles in the final form of the solidified material, which are imperfections that reduce the quality of the material. The present method of control using the rotational constraint aiming at reducing the strength of the convective flow in the chimneys also serve to reduce the presence of chimneys thereby result in producing higher quality materials. We determine the stable and unstable solutions of the weakly nonlinear problem by using perturbation and stability analyses. The presence of rotation was found, in particular, to reduce the tendency for chimney formation at the centers of certain types of two-dimensional cellular patterns and at the nodes on the boundaries of some types of three-dimensional cellular patterns, which appear to be the preferred form of the flow over most of the range of the values of the parameters.

Brief Biography of the Speaker: Daniel N. Riahi joined Dept of Theoretical and Applied Mechanics (TAM) of The University of Illinois at Urbana-Champaign (UIUC) in 1980 and later affiliated with Dept of Mechanical and Industrial Eng (MIE) at UIUC. He served as Full Professor at UIUC from 1995 to 2005 and as Professor Emeritus at UIUC since 2005 with the Home Dept of Mechanical Science and Eng (MechSE) after joining MIE & TAM as a combined MechSE Dept at UIUC in 2006. Professor Riahi also was appointed as Full Professor in the Dept of Math at University of Texas-Pan American since 2006. Dr. Riahi was a Cambridge Univ. (U.K.)-Visiting Scholar in 1986. Earlier than 1980, Dr. Riahi worked at UCLA, Winthrop Univ. and a three-year Post-Doctoral position at the Florida State Univ. (FSU). His academic degrees are Ph.D. in Applied Math (Fluid Mech.) from FSU in1974, M.S. in Math from FSU in 1970 and B.S. in Math from Tehran Univ. in 1966. Dr. Riahi's research work & interest in the last four decades include studies in convection, flow instabilities & turbulence, flow during solidification & crystal growth, and math modeling and theoretical developments with applications to eng and physical sciences. Professor Riahi received UIUC-MechSE &UIUC-TAM Service Appreciation Letters in 2006, a UIUC Service Recognition Certificate in 2006, a UIUC Honorific Title Award in 2005, a UIUC-TAM Recognition Award in 2005. He was included in a UIUC List of Teachers Rank as Excellent by their Students. He is member of over seven professional societies and a Fellow of Wessex Institute of Great Britain. He is author of Chapters in a book on Centrifugal Processing that won the Best Basic Science Book-Award by International Academy of Aeronautics in 1997. Dr. Riahi also received a UIUC-COE Research Award in 1994 and an Outstanding UIUC Service Recognition Certificate in 1987. He is author of over 310 publications mostly published in rigorously referred journals, including books, invited articles and chapters of books. Dr. Riahi's Professional Activities include Chairman of Applied Math at Winthrop Univ. (1977-78), and UIUC Eng Mech Coordinator and Chief Advisor (1985-

86). He was awarded NSF Grants and supervised NASA Sponsored Res. Projects. He also received several UIUC-RB Research Grants and NCSA Awards. He is ABI's Research Board Advisor, Member of the Program Committee of the 4th Int. Workshop on Materials Processing in High Gravity, Member of the Int. Scientific Committees of the 5th and 6th Int. Conferences on Advances in Fluid Mechanics and Member of Int. Scientific Advisory Board of Advances in Fluid Mech. He is Editor & Editorial Board Member of over 15 Technical Journals and Book Series. Dr. Riahi's research accomplishments include new theories, such as those for flow in mushy layers, shear flow over wavy walls, rough turbulence and convective flow in the presence of imperfections, uncovering new types of flow patterns for simple- or mixed-modes and multi-modal cases, and a number of discoveries in fundamental areas of convective and shear flows, some of which were already confirmed by the experimental studies. These include, in particular, flow structure during alloy solidification, roughness roles in turbulent shear flow, flow patterns in layers with finite conducting boundaries and non-monotonic dependence of the heat flux with respect to the rotation rate.

Plenary Lecture IV

The Aeroacoustics of Turbulent Flows

Professor Marvin Goldstein
NASA Glenn Research Center
U.S.A.
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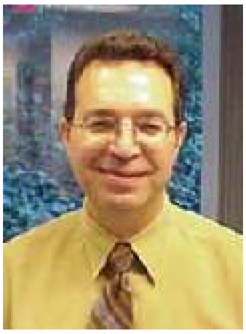
Abstract: Aerodynamic noise prediction has been an important and challenging research area since James Lighthill first introduced his Acoustic Analogy Approach over fifty years ago. This talk attempts to provide a unified framework for the subsequent theoretical developments in this field. It assumes that there is no single approach that is optimal in all situations and uses the framework as a basis for discussing the strengths weaknesses of the various approaches to this topic. But the emphasis here will be on the important problem of predicting the noise from high speed air jets. Specific results will presented for round jets in the 0.5 to 1.4 Mach number range and compared with experimental data taken on the Glenn SHAR rig. It is demonstrated that non-parallel mean flow effects play an important role in predicting the noise at the supersonic Mach numbers. The results explain the failure of previous attempts based on the parallel flow Lilley model (which has served as the foundation for most jet noise analyses during past two decades).

Brief Biography of the Speaker: Dr. Goldstein was chief scientist at the NASA Glenn Research Center from1980 to 2004. His technical accomplishments include a long list of "firsts," including the development of an explanation for boundary layer receptivity to free stream disturbances, a rational analysis of oblique wave modal interactions in shear layers, the theory for the so-called Klebanoff modes that are observed in boundary layers at high to moderate levels of free steam turbulence levels and an analytical solution for the problem of flutter in a cascade with strong in passage shock waves. He also derived the fundamental equation of the compressible rapid distortion theory, which is frequently referenced and is the starting point for many papers in the turbulence literature. Goldstein is an adjunct professor of mathematics at Case Western Reserve University (Cleveland) and has taught at MIT. A specialist in unsteady fluid mechanics with emphasis on transition and stability, unsteady turbomachinery flow, aeroacoustics and aeroelasticity, Goldstein has published over 120 refereed papers, and authored the book "Aeroacoustics" (McGraw-Hill Company, 1976), which has been translated into Russian and Japanese. This book has become the classical reference book for engineers and scientists throughout the world. He has presented many invited and keynote lectures at scientific conferences, symposia and special celebratory events. A Fellow of the American Institute of Aeronautics and Astronautics (AIAA), Goldstein served on the Publications Committee and as chairman of the Aeroacoustics Technical Committee. He is also a Fellow of the American Physical Society (APS), where he served on the Executive Committee of the Division of Fluid Dynamics and the Otto LaPorte Award Nominating Committees. He recently chaired the AFOSR Fluid Mechanics Selection Panel, the Selection Committee for the National Academy of Sciences Award in Aeronautical Engineering and the American Physical Society’s Fluid Mechanics Prize committee. He is also a member of Northeastern University’s Industrial Advisory Board, of the Editorial Board of the International Journal of Aeroacoustics, and of the Scientific Committee of the International Congress of Sound and Vibration. Among his honors is election to membership in the National Academy of Engineering (1990), the APS Otto LaPorte Award for Research in

Fluid Dynamics (now the Fluid Dynamics Prize,1997), the AIAA Aeroacoustics Award (1983), the AIAA Pendray Award (1983) ,Northeastern University's Outstanding Engineering Alumnus Award (2002), and the ASME Fluids Engineering Award (2003). Goldstein received his bachelor's degree in mechanical engineering at Northeastern University (Boston), earned his master's degree in mechanical engineering at the Massachusetts Institute of Technology, and his doctorate at the University of Michigan.

Plenary Lecture V

Two-Phase Flow in Fuel Cells



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Abstract: Polymer Electrolyte Membrane (PEM) Fuel Cells have emerged as one of the most promising energy conversion technologies to help mitigate pollution and green house gas emissions. The effective operation of a PEM fuel cell depends on the optimized regulation of the flow of reactant gases, product water, heat and charged species in conjunction with reaction kinetics. The coupling of these processes and the diversity of media and materials used in fuel cells give rise to a fascinating and challenging array of transport phenomena problems. The formation, phase change and transport of water play a particularly prominent role in determining performance and durability of fuel cells. Net water balance is primarily determined by the water production rate at the cathode, and transport across the membrane via diffusion and electro-osmotic drag. At higher currents, excessive water condensation can lead to "flooding" of the porous electrodes. The resulting blockage of transport pathways for reactant gases can lead to severe performance losses. Excess liquid water often appears in the cathode gas flow micro-channels as well, leading to partial coverage of the gas channel/electrode interface, increased pressure drop, and flow maldistribution. In this talk, we will focus on fundamental aspects of two-phase flow in the micro-channels and in the porous electrodes of fuel cells. The two-phase flow regimes encountered in PEM fuel cells differ significantly from the well documented two-phase flows encountered in more classical engineering applications. Some of the distinguishing features are the fibrous structure of the porous electrodes, the important role of surface forces, and hydrophobicity. Numerical simulations and quantitative visualization experiments will be presented to characterize the liquid water transport processes relevant to PEM fuel cells, and the use of pore network and volume-of-fluid simulation results towards determining some of the macroscopic parameters required for model closure will be discussed.

Brief Biography of the Speaker: After a stint in Industry as an Aerodynamicist, Ned Djilali joined the University of Victoria in 1991 where he applied his expertise in fluid dynamics, transport phenomena and computational modelling to an array of research problems including complex turbulent flows, crystal growth of semi-conductors, novel water purification technology, and energy systems. A major thrust of his research in the last ten years has been fuel cell technology. Djilali is internationally recognized for his pioneering research in computational modelling and design of fuel cells, and for furthering fundamental understanding of the complex fluid, heat and electrochemical processes that take place in this promising clean energy technology. He has consulted and collaborated extensively with industry leaders on the development of state-of-the-art modelling tools and their use in innovative design. Djilali has served as Director of UVic's Institute for Integrated Energy Systems, and has represented UVic on a number of provincial and national strategic R&D initiatives. He has published over 200 papers and book chapters, many of which are highly cited, and holds five patents and several awards, including a Fellowship of the Canadian Society for Mechanical Engineering, the Ludwig Mond Prize from the Institution of Mechanical Engineers, The President's Research Award and the Outstanding Teacher Award of the Engineering Institute of Canada (VI Branch). Djilali served as President of the CFD Society of Canada, and on several editorial boards, including those of the ASME Journal of Fuel Cell Science and Technology and the International Journal of Hydrogen Energy. He currently holds the Canada Research Chair in Energy Systems Design and Computational Modelling at the University of Victoria.

Plenary Lecture VI

Velocity Field Measurements of Various Opaque Flows Using X-ray Imaging Techniques

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Abstract: Flow visualization has become an indispensable tool in the analysis of various transport phenomena. Recent advances in digital image processing techniques have made it possible to extract quantitative flow information from visualized flow images of tracer particles. Optical visualizations or PIV velocity field measurement techniques use commonly lasers as a light source. Because they can be applied only to transparent fluids with clear windows, they are ill-suited in measuring fluid flows confined in opaque materials or non-transparent fluids such as blood. To resolve these limitations, a transmission-type light source such as an X-ray or ultrasonic wave is required. For measuring opaque fluid flows or flows inside opaque conduits, an X-ray micro-imaging technique in which x-ray beam is used as a light source was developed. To visualize flows inside an opaque tube, X-ray beam from the synchrotron radiation source of PLS (Pohang Light Source) was used. In the X-ray micro-imaging, the refraction or Fresnel edge diffraction mechanism was adopted to improve the image quality. The relative weights of the refraction and Fresnel diffraction depend on the given experimental conditions, the type of specimen, and the information to be extracted. Using the X-ray micro-imaging technique, several opaque flows were visualized quantitatively. Examples include a glycerin flow inside an opaque Teflon tube, sap flow inside xylem vessels of a bamboo leaf, blood flow and micro-bubbles moving in an opaque tube.

Brief Biography of the Speaker: Professor Sang-Joon Lee recieved his BSc in 1980 from Busan National University, his MSc in 1982 from Korea Adv. Inst. of Sci. & Tech. (KAIST), and his PHD in 1986 from Korea Adv. Inst. of Sci. & Tech. (KAIST). His main research interests are : Experimental Fluid Mechanics, Advanced Flow Visualization, Micro-fluidics and Bio-fluid Flows, Flow Control, Turbulence, Bluff Body Aerodynamics, Wind Engineering,. Dr Sang-Joon Lee has a great academic and industrial experience with: a) Korea Inst. of Machinery and Metal from 1986. 2 - 1986. 12 as Senior Researcher , b) Imperial College, London from 1988. 9 - 1989. 9 as Visiting Professor, c) Johns Hopkins University from 1996. 8 - 1997. 8 as Visiting Professor , d) Pohang Steel & Iron Co. (POSCO) from 1991. 1 - Present as Advisory Professor, and e) POSTECH from 1987. 1 – Present as a Professor, f) National Research Lab.(Flow Visualization) from 2000. 6 - Present as Principal and g) Investigator and Advanced Fluid Engineering Research Center, from 2006. 1 – Present as Director. He has also involved in different acadamic and social activities . For instance in, International Journal “Wind & Structures”as International Editorial Board Member , International Journal “Journal of Visualization”as Regional Editor , International Journal of Vascular Biomedical Engineering as Editor, KSME Journal; as Editor for Fluid Mechanical division, Wind Eng. Institute of Korea: director (1997-2003) as vice president (2003-) , Korea Soc. of Visualization (KSV): director (2001-) as vice president (2005-), KSV Journalas Chip editor, Biomedical Eng. Society for Circulatory Disorders : director (2001-), as vice president (2005-), SME, AIAA, JSMEas Member , Asian Fluid Mechanics Committee, Member and

Assembly of World Conferences on Exp. Heat Transfer, Fluid Mech. & Thermodynamics.as Member. He has recieved several awards from : a) Namheon Academic Award, KSME, 1997 b) Academic Award, KSME, 1998 c) JeChul Technology Award, POSCO, 1999, 2000 d) Best Paper Award, SNAK, 2003 e) Korea Patent Grand Exhibition, Silver Medal, 2003 f) JOV Award, Visualization Society of Japan, 2007.

Plenary Lecture VII

Fluid and Heat Transfer Issues in Aircraft Fires and Explosions

Dr. N. Albert Moussa
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Abstract: While commercial air travel is an extremely safe mode of transportation, aircraft fires and explosions can occasionally occur with catastrophic consequences to passengers and crew. These accidents are also the driving force behind the safety improvements required or recommended by governmental agencies and adopted by industry. Based on real-world examples, Dr. Albert Moussa will provide an overview of the main types of in-flight and post-crash fires involving aircraft engine, fuel tank, cabin and cargo areas. He will also give examples of safety improvements such as the recent requirements of inerting fuel tanks and fire hardening thermal acoustic insulation. His presentation will identify key fluid and heat transfer issues that pervades this subject. This is a multi-media presentation illustrated with slides, computer model output and short video clips.

Brief Biography of the Speaker: He is the Founder and Technical Director of BlazeTech Corp. in Cambridge, MA, a company that specializes in R&D in the areas of safety, environment and energy. He specializes in fire and explosion working particularly for the aircraft and chemical industries. He has developed and teaches an annual four-day professional engineering course on this subject that is unique in bridging the gap between theory and practice. He got his B.S. from Stanford University and his MS and PhD from MIT, all in Mechanical Engineering. He has published widely including one book on flammability. His forewarning about fuel tank vulnerabilities prior to the TWA 800 and Concorde disasters has gained him notoriety in the US and international media. He has received many awards, most recently the Engineer of the Year Award from the New England Section of the AIAA in 2000, the Distinguished Lecturer award by the AIAA in 2004, and best paper awards by SAE in 2005 and ASEI in 2006.

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