Recent Advances in Fluid Mechanics and Heat & Mass Transfer

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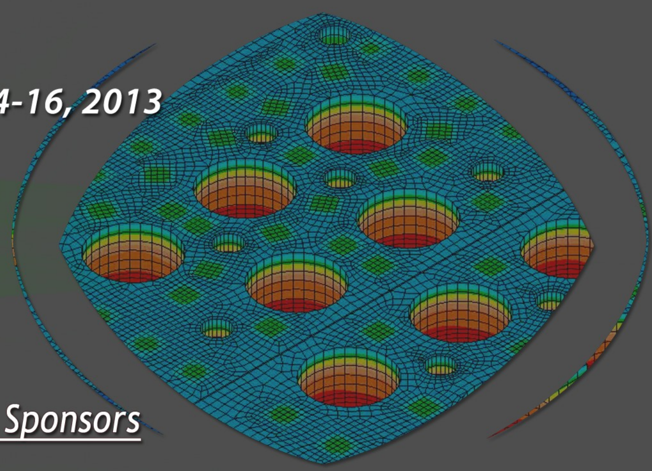
Proceedings of the 11th International Conference on Fluid Mechanics & Aerodynamics (FMA '13)

Proceedings of the 11th International Conference on Heat Transfer, Thermal Engineering and Environment (HTE '13)

Vouliagmeni, Athens, Greece, May 14-16, 2013



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Preface

This year the 11th International Conference on Fluid Mechanics & Aerodynamics (FMA '13) and the 11th International Conference on Heat Transfer, Thermal Engineering and Environment (HTE '13) were held in Vouliagmeni, Athens, Greece, May 14-16, 2013. The conferences provided a platform to discuss mathematical modeling in fluid mechanics, multiphase flow, material properties, hydrodynamics, water resources management, aerodynamics, aviation, heat and mass transfer, environmental protection, solar energy etc with participants from all over the world, both from academia and from industry.

Their success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The accepted papers of these conferences are published in this Book that will be sent to international indexes. They will be also available in the E-Library of the WSEAS. Extended versions of the best papers will be promoted to many Journals for further evaluation.

Conferences such as these can only succeed as a team effort, so the Editors want to thank the International Scientific Committee and the Reviewers for their excellent work in reviewing the papers as well as their invaluable input and advice.

The Editors

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Plenary Lecture 1

Instability and Three-Wave Interactions in Supersonic Boundary Layers

Professor Sergey A. Gaponov
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Abstract: The problem of laminarization of viscous flows became topical in connection with an important practical problem, namely, the problem of reducing friction drag. As a rule, laminar-turbulent transition is initiated by unstable oscillations growing downstream, and therefore suppression of the instability wave leads to an increase in the length of the laminar flow section. In the paper the disturbances development in supersonic boundary layer is considered within the framework of the linear and weakly nonlinear stability theory for the Mach number M = 2; 5.3 on the soled, porous and flexible surfaces. The special attention is paid to three - wave interaction. On a porous surface at M = 5.3 acoustic and vortex waves in resonant three-wave systems are found to interact in the weak redistribution mode, which leads to weak decay of the acoustic component and weak amplification of the vortex component. Three-dimensional vortex waves are demonstrated to interact more intensively than two-dimensional waves. Vanishing of the pumping wave, which corresponds to a plane acoustic wave on a solid surface, is found to assist in increasing the length of the regions of linear growth of disturbances and the laminar flow regime. At M = 2.0 it was established that three-wave resonant interaction is stronger for non-symmetric triplet at M=2 on the impermeable surface, and such nonlinear interactions become even stronger on the porous surface in comparison to impermeable surface. For flexible coverings it was established that them an influence on a stability of a boundary layer considerably even in case of a gas stream. At moderate supersonic speeds application of thin flexible coverings leads to flow stabilization, at least, in the field of large Reynolds's numbers. At high Mach numbers, for example for M=5.3, the area of low Reynolds's numbers where destabilization of the second mode is observed, extends in comparison with case M=2.0. However at Reynolds's numbers answering to the greatest instability at a rigid surface, the flexible covering stabilizes a flow. As a whole flexible covering destabilizes vortical and stabilizes acoustic disturbance both on linear and on nonlinear development stages.

Brief Biography of the Speaker: Sergey Gaponov graduated from the Physics Department of Novosibirsk State University, Russia in 1964. With 1965 till April he works in the Khristianovich Institute of Theoretical and Applied Mechanics of Siberian Branch of Russian Academy of Science as Junior and Senior Scientific Researcher, Head of Laboratory. Now he is Main researcher of the same Institute. With 1992 he works also as Professor of the Department of Theoretical Mechanics, Novosibirsk State University of Architecture and Civil Engineering. S. Gaponov is the expert in a field of the fluid and gas mechanics. The basic directions of his scientific activity are connected with researches of hydrodynamic stability, non-stationary processes and the turbulence occurrence in supersonic gas flows. He defended the candidate thesis "Stability of the incompressible boundary layer on a permeable Surface" (1971) and doctor thesis (physics and mathematics) “Development of disturbances in a supersonic boundary layer” (1987). He is member of Council on a defence of doctoral theses at Institute of Theoretical and Applied Mechanics, member of Russian National Committee on Theoretical and Applied Mechanics, member of the International Scientific Committee on Fluid Mechanics and Aerodynamics. The prize of Zhukovsky was awarded to him. There are many grants for fundamental research in which he took part: Grant of International Science and Technology Center: ISTC-128-96 investigator, Grants of Russian Foundation for Basic Research (team leader.) He took part in work of numerous scientific conferences, including the Fluid Mechanics and Aerodynamics conferences. Number of his papers in refereed journals is more than140. Two books were published.

Plenary Lecture 2

Boundary Layers Modeling for Developing Turbulent Flow

Professor Sabah Tamimi
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Abstract: One of the important applications of Engineering and applied Computer Science disciplines is the fluid motion which can be represented by the Navier-Stockes (N-S) equations. An analytical solution is intractable to be obtained this is due to the complexity of these equations and due to the growth of technology, these applications take advantage of the increasing speed of computers and hardware capabilities. Therefore, as alternative methodology, is the so called computational fluid dynamics (CFD) which has been developed and used with confidence to solve set of non linear partial equations which can simulate the flow process and solve a large range of flow problems and at the same time can offer a cost-effective to many fluid problems especially where experimentation is extremely difficult to obtain. Numerous theoretical and experimental works are available on laminar flow, but this is not the case of turbulent flow. Since it has not been possible to obtain exact analytical solutions to such flows, an accurate numerical approach would be very beneficial to researchers. The finite element method (FEM) recently emerged as a powerful tool for solving the N-S equations. In the present work, the finite element method is used to discretise the equations governing the fluid motion within the computational domain (main domain). An effective technique is required to model the variation in velocity and kinetic energy, which is extremely large near the solid wall since the transfer of shear form the boundary into the main domain and the nature of the flow changes rapidly. The general use of conversational finite element elements up to the wall is not economically viable. Since a significant grid refinement would be required this would be costly in both computer storage and C.P.U. time. A more common approach is to terminate the actual domain at some small distance away from the wall, where the gradients of the independent variables are relatively small, and then another technique is needed to model the flow behavior in the near wall zone. The most traditional technique is the utilization of empirical universal laws. It is found that these laws are not valid in general, since these laws are really applicable for certain unidimensional flow regimes. Presently, a wall element technique, based on the use of the finite element method has been adopted and applied successfully for turbulent flow. This technique can be used with confidence and replaces other techniques. This lecture will present the validity of the wall element technique to simulate developing turbulent flow.

Brief Biography of the Speaker: Dr. Sabah Tamimi holds a M.Sc. in Computer Science (1988) and a Ph.D. in Applied Computer Science (1992), both of them from University of Wales, UK.
He is working continuously as a full-time academic faculty for more than 21 years at university level. In addition, the last 11 years, he has been involved in administrative sector working as Deputy Dean and Dean as well as faculty. He is currently an Associate Professor at the College of Engineering and Computing, Al Ghurair University, United Arab Emirates. His research interests include: computer modeling and simulation, computational flow dynamics, software testing techniques, computer graphics and databases. He has a very good number of publications in International journals and conferences proceeding (of IEEE, WSEAS, etc.), and reviewed many papers for international journals and conferences. Also, he is an editorial board member of different international journals.

Plenary Lecture 3

An Industrial Ecology Strategy for Preventing Thermal and Chemical Pollution of Waterbodies Caused by Geothermal Liquid Discharges

Professor Fragiskos Batzias
Laboratory of Simulation of Industrial Processes
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Abstract: Industrial Ecology (IE) is a methodological framework that deals with energy and materials flows within a system of inventories and processes, including natural resources and the environment. This framework can be used for the maximization of system's sustainability by optimizing each constituent unit separately and their combination as a whole. Geothermal energy, under the form of high temperature (>150 oC) liquid, can be used for operating three major types of power plants: dry-steam, flash-steam, and binary-cycle. Geothermal liquids of moderate or lower temperature X (i.e., 150 oC>X>90 oC and X<90 oC, respectively) are frequently used for direct applications, like district or space or greenhouse heating, aquaculture (especially fish-farming), and heat exchanging in industrial processes, including decentralized units (e.g., for desalination). On the other hand, the spent liquid may cause chemical and thermal pollution in the waterbodies where it is discharged due to its (i) relatively (to the ambient) elevated temperature and (ii) high concentration of polluting elements. In this work, an inter-/multi-disciplinary approach is adopted, based on economic/technical/environmental criteria for determining the optimal subsidy to be granted by the State in order to facilitate exploitation of geothermal fields in a sustainable way. For this purpose, an objective function is synthesized in economic terms, where technical/environmental factors enter as control variables/parameters and constraints/restrictions. Since, in the time course, energy and materials prices rise, the exploitation of geothermal fields of lower enthalpy becomes feasible while recycling of certain polluting elements seems promising. An implementation for a Greek island of the Aegean Sea is presented and the results are discussed.

Brief Biography of the Speaker: Prof. Fragiskos Batzias holds a 5years Diploma and a PhD degree in Chemical Engineering, and a BSc in Economics. He has also studied Mathematics and Philosophy. He is Director of the Laboratory of Simulation of Industrial Processes and Head of the Research Group on Systems Analysis at the Department of Industrial Management and Technology of the University of Piraeus, Greece. He is teaching at the interdepartmental postgraduate courses (i) Systems of Energy Management and Protection of the Environment, running by the University of Piraeus in cooperation with the Chem. Eng. Dept. of the Nat. Tech. Univ. of Athens, and (ii) Techno-Economic Systems, running by the Electr. & Comp. Eng. Dept. of the Nat. Tech. Univ. of Athens in cooperation with the University of Athens and the University of Piraeus. His research interests are in chemical engineering systems analysis and knowledge based decision making. He has >100 publications in highly ranked journals and conference proceedings, including 29 research monographs in collective volumes, with 171 citations and an h-index of 8 (for the period 2004-2012, source: ISI Web of Science, Thompson Scientific; self-citations have been excluded).
He has participated (and chaired after invitation from the organizers) in prestigious international conferences, such as those organized periodically by the IEEE, the European Federation of Chemical Engineering (EFCE), the DECHEMA, CHISA, WSEAS Organizations. He organizes the annual Symposium on Industrial and Environmental Case Studies running successfully since 2004 within the International Conference of Computational Methods in Sciences and Engineering (ICCMSE).

Plenary Lecture 4

Heat Transfer Processes with Boiling in Extended Surfaces – Approximate and Exact Solutions

Professor Andris Buikis
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Abstract: Systems with extended surfaces (with fins, spines and/or nanostructures) have very broad field of applications: from space apparatus, engines, conditioners, fridges etc. till cooling systems for microchips of PC. Modern servers use the fluid boiling heat transfer. From praxis point of view the mathematical description (mathematical models) must be formulated as conjugated problem. We have developed some new models for boiling performance for micro-nano hybrid structure via silicon nanowire arrays.
Intensive quenching (IQ) processes are one of important branches of to day's metallurgical technologies. In ecologically clean steel quenching processes important aspect is the heat exchange with the surrounding cold water. But the type of heat exchange is mostly defined by initial heat flux densities. If the initial heat flux density is less, then on the sample's surface the nucleate boiling establishes. In 2005 we proposed the hyperbolic heat equation as mathematical model for intensive steel quenching process. In several papers during 2005-2011 we have developed some approaches (Green function method, original conservative averaging method) for the solving of the direct and time reverse problems for the hyperbolic heat equation.
In this talk we present original (based on the Green function generalization method and conservative averaging method) approach for the determination of the exact and approximated solutions in the systems with extended surfaces of quite complicated geometrical and thermal structure. By modeling practically interesting processes, very often we need to consider the situation, when the medium has a layered structure. Speaking mathematically, such situation can be described by PDE (or its system) with piecewise constant coefficients. In this lecture I'll show how conjugations conditions, non-ideal contact conditions etc. and their generalizations can be obtained by our original method of conservative averaging (CAM). The usage of CAM for separate relatively thin sub-domain or/and for sub-domain with large medium characteristic, leads to reduction of domain, in which the solution must be found.

Brief Biography of the Speaker: Andris Buikis received the M.S. in numerical mathematics from University of Latvia (Faculty of Physics and Mathematics) in 1963 and Dr. math., University of Latvia, 1970. He was Junior Researcher, Senior Researcher, Computing Centre, University of Latvia, 1962 – 1972. Assistant Professor and Head of Chair of Applied Mathematics, 1972 – 1976 and Head of Chair of Differential Equations and Numerical Methods, Faculty of Physics and Mathematics, University of Latvia, 1976 – 1984. Dr. habil. math. (Doctor of Science in former USSR), University of Kasan, Russia, 1988. Professor, University of Latvia, 1991. Director, Institute of Mathematics, Latvian Academy of Sciences and Latvian University, 1991 - 1996; 2003 – 2006 and Director, Science and Dialogue Centre of Latvia, 1993 -2007. Head of Laboratory of Mathematical Technologies, Institute of Mathematics and Computer Science, University of Latvia 2006-2010.
In 2010 he was elected as Member of Saeima (Parliament of Latvia). Full Member, Latvian Academy of Sciences, 1997. Member, Senate of the Latvian Academy of Sciences, 1994 –2011. The first, who received Piers Bohl Prize established by Latvian Academy of Sciences for a cycle of papers "Method of Conservative Averaging, Theory and Applications", 2005. Member of Editorial Advisory Board, Journal Mathematical Modelling and Analysis (The Baltic Journal on Mathematical Applications, Numerical Analysis and Differential Equations), Lithuania 1999- and Associate Editor of WSEAS Transactions in Heat and Mass Transfer 2007-, Associate Editor of Journal of Vortex Science and Technology, 2011-.

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Plenary Lecture 5

Thermal Destruction Modeling for Refractory Materials

Dr. Andrew Zabolotsky
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Abstract: Thermal destruction is one of the main reasons of metallurgical installations refractory linings fail, sometimes at the very beginning of their usage. The cause of destruction is mechanical strain, produced by thermal growth or compressing of material. Modern mathematics methods, such as FEM, allow calculating of so-called Dynamic Temperature Field (DTF), which is an initial data for further mechanical calculations. Numerous publications were devoted to the description of FEM usage for different industrial processes, metallurgy in particular. The calculation process has several difficulties, needed to be taken into consideration, commonly while working with 2D or 3D models. Mostly these difficulties could be annihilated while data preparation. For mechanical calculations a method of Moving Cellular Automata (MCA) is most convenient. This method could be used for complete DTF analysis or as a parallel calculation while DTF providing with FEM. Most publications describes so-called homogeneous method usage (it means, that each automata contain only one chemical phase). An author used a heterogeneous type of the method, where every automata had it's own inner structure and was a container of several chemical phases and a combination of several small solid bodies. So, a rule of such automata destruction was prepared and used as a base of an original software project. This software was used for destruction modeling of iron casting mold and refractory lining of RH-degasser. The results were not against experimental data received.

Brief Biography of the Speaker: Andrew V. Zabolotsky was born in St. Petersburg, Russia in 1975. He had graduated from St. Petersburg State Institute of Technology (Technical University), department of High-Temperature Materials in 1998. He had defended a thesis about technology of silicon nitride ceramics and received PhD degree in technical sciences in 2002. After graduating he worked at JSK “Sigma-T” (2000-2002) – a producer of high temperature testing equipment for ceramics and refractory materials as a head of heat insulation department. Between 2002 and 2004 he was a technologist at laboratory of “Refractory materials ltd.”, a company which produced refractory concrete for iron and steel industry. At the present time he is an engineer-technologist of “Magnezit Group ltd.” – one of the main producers of periclasse-carbon refractory materials in Russia and Europe. He had prepared about 30 papers for different journals in Russia and other countries (mostly between 2009 and 2013). He was a participant of several international conferences (for example IAS Conference in 2009 at Buenos Aires, Argentina, WSEAS Conference in Puerto de la Cruze, Spain in 2010). He is WSEAS (since 2010) and AIST (Association of Iron and Steel Technology) member since 2011. At the present time he is working with problems of heat exchange in refractory linings of metallurgical installations and using of mathematics methods for emergency forecasting in metallurgy. Also he is interested in thermal cracks growth modeling for brittle materials such as refractory ceramics and iron.

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Plenary Lecture 6

Current Issues and Methodology to Evaluate Air Quality in Airport Areas

Assistant Professor Francisc Popescu
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Abstract: Interests in aircraft and airport air pollutant emissions have been rising since the substantial increase in commercial turbojet traffic in the 1970's. For example, aircraft emissions produce air contaminants such as NOx, HC, and fine particulate matter (PM), which in turn can become involved in broader environmental issues related to ground level ozone (O3), acid rain, climate change, and present potential risks relating to public health and the environment. According to estimates of the Intergovernmental Panel on Climate Change (IPCC), international aviation contributes about 3.5 % to global warming. International aviation is therefore becoming increasingly responsible for the greenhouse effect and pollutants emissions as well, but is nevertheless not covered yet by the Kyoto Protocol. In contrast to international aviation, greenhouse gas emissions of national aviation are included in the Kyoto Protocol. Fuels used in international air and maritime traffic – so-called bunker fuels – are excluded from reduction and stabilization commitments for the first commitment period (2008 - 2012), because agreement could not be reached on the question of the assignment of such emissions. In this context we conducted an air quality monitoring campaign in the Traian Vuia International airport, by means of point monitors for NOx, SO2, CO, O3, PM10, NMHC (VOC) and also open path Differential Optical Absorption Spectrometry (DOAS). The results obtained are interesting and rising questions that will be presents and discussed thru the lecture.

Brief Biography of the Speaker: Dr. Francisc Popescu obtained its engineering degree at "Politehnica" University of Timisoara in 1999. In 2001 he finished his Master training in environmental engineering (energy and transportation) and from 2004 holds a PhD degree, cum laude, both at "Politehnica" University of Timisoara. In this period he had several research stages at T.U. Graz Austria, MLU Austria and in T.U. Munchen as A.v. Humboldt young research fellow. His professional interest is in environmental topics, mainly air quality and renewable fuels. He coordinated several research projects funded thru Romanian Government, Balkan Environmental Association and EU programmes and also participated as senior researcher in over 20 research projects with FP6, EU or national funding. He authored or co-authored several books and numerous scientific papers in conference proceedings or journals, most of them indexed in prestigious scientific databases. Some of his research was included in 3 patents and distinguished Gold Medals for new products at iENA2010 and iENA2012, Nuremberg.

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Plenary Lecture 7

Electric Battery Storage for Hybrid Vehicles: State-of-the-Art Review and Challenges

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Abstract: Development of hybrid electric vehicles is of great interest to the transportation industry due to increased demand and cost of gasoline and diesel oil, uncertainty in the steady supply of oil, and increased standards for reduced emissions. This necessity for reducing fuel consumption and emissions led to the development of the concept of hybrid electric vehicles which is dual powered by gasoline or diesel engines with larger battery, hybrid powertrain and electric motors. This leads to improved performance, lower gas consumptions and lower CO2 emission. Electrical energy is lost from electric vehicles in the form of heat during dynamic braking. Recovering this energy using a regenerative braking system and storing it in battery stacks and using it later for propulsion and acceleration can improve the overall efficiency and reduction of fuel consumption. Lithium-Ion batteries are considered as one of the leading types as compared to the other batteries for the battery systems to be employed in electric vehicles (EVs) or hybrid electric vehicles (HEVs). Some of the major challenges with the full-scale commercial use of Lithium-ion batteries for electric or hybrid vehicles are the requirement of high energy and power densities, compatibility with high charge and discharge rates for different load cycles while maintaining high performance, and prevention of any thermal runaway conditions. Recent research and development activities, major technical issues and future research focus of electric battery are reviewed. Experimental, modeling and simulation analysis is presented for electrochemical and thermal characterization of a lithium-ion battery subject to a range of charge and discharge loading, and thermal environmental conditions.

Brief Biography of the Speaker: Pradip Majumdar is a Professor of Mechanical Engineering, Director of Heat and Mass Transfer laboratory, and Director of Undergraduate studies in the Department of Mechanical Engineering, Northern Illinois University, DeKalb, Illinois. He received his BS in mechanical engineering form B.E College, University of Calcutta, and MS and Ph.D. in mechanical engineering from Illinois Institute of Technology, Chicago. He has worked as a design engineer on a Nuclear power plant project for DCL in Bombay, India from 1975-1977. His specialty and research activities include Thermo-fluid Sciences, Computational Fluid Dynamics (CFD) and Heat Transfer; Fuel Cell Energy and Battery Storage System, Solar Thermal Energy Systems; Hydrogen storage; Heat and Mass Transfer in Porous Media; Micro-Nanoscale Fluid Flow and Heat transfer; High Heat Flux Electronics Cooling, High Energy Laser Material Processing, CFD Analysis of Scour Formation, Blood flow in Human Arteries and Stent Design, and Laser Treatment of Tumors. He has published over 90 peer reviewed technical papers in archival journals and conference proceedings. He has received 2008 Faculty of the year award from NIU. He has published a book on Computational Methods for Heat and Mass Transfer. He is also the author of an upcoming book on Fuel Cell. He is serving as the Editor-in-Chief for Transactions on Fluid Mechanics. He served as a guest editor for special issues on advances in electronics cooling in the Journal of Electronics Manufacturing. As a member of ASME, he has serves on the technical committee for Computational Heat Transfer, Heat Transfer on Electronics and Energy Systems. He has organized and chaired many ASME and InterPack conferences sessions on Fuel Cells, Micro-Nano Scale Heat Transfer, Electronics Cooling and Computational Heat Transfer.

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