Editors

Guoxiang Liu
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Recent Researches in Mechanical Engineering

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- **Proceedings of the 10th WSEAS International Conference on Fluid Mechanics (FLUIDS '13)**
- **Proceedings of the 10th WSEAS International Conference on Heat and Mass Transfer (HMT '13)**

Milan, Italy, January 9-11, 2013

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Preface

This year the 10th WSEAS International Conference on Fluid Mechanics (FLUIDS '13) and the 10th WSEAS International Conference on Heat and Mass Transfer (HMT '13) were held in Milan, Italy, January 9-11, 2013. The conferences provided a platform to discuss mathematical modeling in fluid mechanics, material properties, hydrotechnology, nano-fluids, plasma engineering, molecular dynamics, heat and mass transfer, thermal engineering, continuum mechanics, management of heating resources, solar energy, waste management and energy production, urban areas and heat pollution 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

Modelling and Simulation of Particle-Laden Flows in Engineering Applications

Professor Konstantin Volkov
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Abstract: Industrial activity of modern society is often concerned with suspensions of solid or liquid particles in gas or fluid flows. The role of particles and droplets in environmental and engineering applications is two-fold. On the one hand, particles and droplets may pose potential hazard for human activity (erosion of surface and deposition of aerosols in human lungs). On the other hand, particles or droplet can be successfully used in engineering solutions (to induce working processes in energy systems and to suppress acoustic instabilities of thermal processes). Processes that control transport and combustion of particles and droplets in turbulent flows remain unresolved, and introduce significant uncertainties into modeling and simulation. Modeling of particles dynamics within the existing CFD models suffer from lack of currently available knowledge in particle microphysics. This lecture is aimed to quantify and to monitor particle/droplet motion in turbulent flows, and to create tools for reliable prediction of particle evolution and transport. In computer modeling of particle/droplet laden turbulent flows, particular attention is focused on improvement of existing models of particle evolution and combustion, and on advanced turbulence modeling. Both Euler and Lagrangian approaches are applied in modeling particle evolution, including vaporization, sedimentation, transport and dispersion of aggregates of complex morphology. Large-eddy simulation and Reynolds averaging techniques are used for turbulence modeling. Lagrangian stochastic approach is applied to model particle dispersion in turbulent flows. The possibilities of the computational tools developed are demonstrated using a number of model problems and case studies (internal gas-particles flows in complex channels, external gas-particle flows, explosion and detonation in gas-particle and gas-droplet systems and others). Weaknesses in the models are identified and suggestions made for possible improvements.

Brief Biography of the Speaker: Dr Konstantin Volkov is a senior lecturer in themofluids at the Kingston University (London, UK). He holds a PhD in fluid mechanics and his dissertation was on simulation of thermal processes in energy systems (St Petersburg State University, Russia, 1998). He also holds two Master degrees. The first one is in thermal engineering and his dissertation concerned simulation of internal flows in engineering applications (Baltic State Technical University, Russia, 1996). The other one is in mathematics and computer science and his dissertation was on modelling and simulation of turbulent two-phase flows in energy systems (St Petersburg State University, 1997). He has been working as a lecturer and researcher in multidisciplinary areas. After completion of his PhD, Dr K Volkov worked as a researcher and lecturer at the Baltic State Technical University in Russia for 6 years, the Centre for Research in Fire and Explosion Studies of the University of Central Lancashire in UK for 2.5 years followed by 6.5 years at the Rolls–Royce University Technology Centre in Thermofluids Systems of the University of Surrey in UK. He joined the Kingston University team in 2009. His areas of expertise cover multidisciplinary areas: from applied engineering problems related to design and optimization of energy systems to fundamental problems focused on computational fluid dynamics and mathematical modelling. Dr K Volkov is the Chartered Engineer and the member of the Institute of Physics, Institution of Mechanical Engineers and Combustion Institute. He is the editor, author or coauthor of 6 books, 6 invited book chapters, more than 120 scientific papers and the member of the editorial board and scientific committee of a number of scientific journals and conferences.

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Plenary Lecture 2

PIV Measurement of Flow around an Arbitrarily Moving Body

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Abstract: This paper presents a PIV (particle image velocimetry) image processing method for measuring flow velocities around an arbitrarily moving body. This image processing technique uses a contour-texture analysis based on user-defined textons to determine the arbitrarily moving interface in the particle images. After the interface tracking procedure is performed, the particle images near the interface are transformed into Cartesian coordinates that are related to the distance from the interface. This transformed image always has a straight interface, so the interrogation windows can easily be arranged at certain distances from the interface. Accurate measurements near the interface can then be achieved by applying the window deformation algorithm in concert with PIV/IG (interface gradiometry). Quantitative evaluations of this method were performed by applying it to computer-generated images and actual PIV measurements. A three-dimensional (3D) particle image velocimetry (PIV) measurement technique capable of simultaneously monitoring 3D fluid flows and the structure of an arbitrarily moving surface embedded in the flow is proposed. An optimal exposure time for surface and particle imaging was identified using red fluorescent tracer particles in conjunction with a long-pass glass filter. The particle image and surface image were then separated using an image separation process that relied on the feature scaling differences between the particles and the surface texture. A feature detection process and a matching process facilitated estimation of the 3D surface points, and the 3D surface structure was modeled by Delaunay triangulation. The particle volume reconstruction algorithm constrained the voxels inside the surface structure to zero values to minimize ghost particle generation. Volume self-calibration was employed to improve the reconstruction quality and the triangulation accuracy. Three-dimensional experiments that modeled the flows around an eccentric rotating cylinder and a flapping flag were conducted to validate the present technique.

Brief Biography of the Speaker: Hyung Jin Sung received his Ph.D. degree in Mechanical Engineering in 1984 from KAIST (Korea Advanced Institute of Science & Technology), Korea. He is a professor in the department of Mechanical Engineering, KAIST. His current research interests include turbulence, flow control, measurement, flow-structure interaction, micro/bio fluidics, and fuel cell. More recent contributions have explored the liquid transfer on printed electronics. Since 1986 he has served as visiting professor in UIUC, Hokkaido University, and UCLA for several years. Prof. Sung has served on a chief of fluid engineering of KSME (Korean Society of Mechanical Engineers). He conducted a research in collaboration with Cavendish laboratory of Cambridge University and developed micro devices for fluid mixing and pumping. Since 1997 he has received academic awards from KSME and KAIST. Moreover, in 2003 he won a commendation from the President of Korea in appreciation of his research. He is author of about 190 papers published in international journals.

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Plenary Lecture 3

3D Holographic PTV Measurements of Micro-Scale Flows

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Abstract: Holographic PTV (HPTV) is one of powerful means to get 3D (three-dimensional) velocity field information of flows. A micro-HPTV technique was developed and applied to measure 3D velocity fields of various micro-scale flows, including the flows in straight and curved micro-tubes having a circular cross-section and the 3D motion of red blood cells in a micro-tube. The inertial migration of neutrally buoyant micro-spheres suspended in a micro-tube was also investigated with varying Reynolds number and particle size. In addition, the motile characteristics of 3D motion of free-swimming chain-forming phytoplankton having different number of cells in various configurations were analyzed using the micro-HPTV technique. From time-varying 3D trajectories of swimming microorganisms, their swimming behaviors and swimming motion parameters were extracted successfully. Through these experiments, the micro-HPTV method was found to have strong potential in the accurate measurements of temporal variations of 3D velocity fields of various micro-scale flows and 3D motility of RBCs and microorganisms.

Brief Biography of the Speaker: Sang Joon Lee: He received his MSc and Ph.D. from Dept. of Mechanical Eng. of KAIST(Korea Advanced Institute of Sci. & Tech.) in 1982 and 1986, respectively. In 1986, he worked as a senior researcher at Korea Institute of Machinery Metallurgy. He joined the Dept. of Mechanical Eng. at POSTECH as an assistant professor in 1987 January and he became a full professor in 1999. He was selected as a POSTECH fellow on 2010. His laboratory was designated as a National Research Lab. on 2000 and CRI (Creative Research Initiatives) center on 2010 by Korea government. His research interests include biofluid flow, microfluidics, flow control and advanced flow visualization.

Plenary Lecture 4

Tomographic PTV

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Abstract: A new tomographic PTV(Tomo-PTV) was proposed and its performance was compared with the tomographic PIV(Tomo-PIV). In order to construct the new tomographic PTV for the calculation of the vector fields, an affine transformation was newly introduced. Initial vectors were obtained by the match probability method, and were used for the calculation of the affine transformation in order to get the final vectors. Four-camera based tomographic PTV system was constructed. By adopting a new factor called degree of reality, the real particles were easily separated from ghost particles groups in the reconstructed tomographic voxel images. Two types of flows, a ring vortex and an impinging jet, were tested by the constructed tomographic PTV, and their results were compared with those obtained by the conventional tomographic PIV. The construction method for the voxel images was MLOS-MART method. Strong points and weak points of the two measurement methods, tomo-PTV and tomo-PIV were made.

Brief Biography of the Speaker: Deog Hee DOH received his Ph.D. degree in the Department of Mechanical Engineering in 1995 from the Tokyo University, Japan. He is a professor in the department of Mechanical and Energy Systems Engineering, Korea Maritime University. His current research interests include quantitative flow visualizations, developments of non-contact measurement techniques, and their application to ship and offshore machinery. Most recent research work is the development of the tomographic PTV. He served as a visiting researcher at POSTECH (1995), and as a visiting professor at the Nihon University (2003, 2004). Prof. DOH is now serving as a vice chairman of KSV (Korean Society of Visualization). He is vice editor of KSME (Korean Society of Mechanical Engineers) journal in FED (Fluid Engineering Division). He conducted collaborative research works with Oshima laboratory of the Tokyo University and developed a measurement technique which can measure the motion of flexible body and the flow inside of the body. He is author of about 100 scientific journals.

Plenary Lecture 5

Use of Computational Fluid Dynamics and Fluid-Structure Interaction to Simulate the Cardiovascular System

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Abstract: Abstract The aim of this session is to discuss how computational methods can be used to investigate the fluid dynamics of the cardiovascular system. The session will focus on the heart and its natural valves. This is important as heart valve failure leads to fluid dynamics which are detrimental to the cardiovascular system that require surgery for correction. In the United Kingdom, the British Heart Foundation has estimated that cardiovascular disease is the cause of one out of every three deaths.
Computational methods provide a non-invasive method to investigate the cardiovascular system. In particular computational fluid dynamics and fluid-structure interactions are useful as they can be used to predict fluid dynamics. The former enables shear stresses to be predicted, while the latter enables the induced stress and deformation to be predicted. Such predictions are useful when either understanding pathology or investigating surgical repair or replacement. However, use of computational fluid dynamics on its own ignores moving structures (e.g. heart valves) which can lead to inaccurate predictions of stress and flow. Fluid-structure interaction simulations can solve some of these limitations, for example, through the use of an Arbitrary-Lagrange Euler moving mesh. Its use, though, introduces further technical challenges such as contact modelling or including relatively large deformations in models (e.g. 10 – 20% strain).
Further challenges include selection of representative geometry, boundary conditions, material properties for blood (e.g. viscosity) and soft tissues (e.g. heart valve Young's modulus). In the case of geometry or boundary conditions a major problem is accurate measurement. Defining suitable material properties presents the problem of large variability associated with natural tissues (e.g. heart valves). Currently in our laboratory we have been using both computational fluid dynamics and fluid-structure interaction to aid understanding of the cardiovascular system focusing on heart valves but also aid diagnosis and investigate failure of heart valves.
The session includes:
- background to the cardiovascular system, in particular the heart and its natural valves;
- description of the basic physiology involved in the heart and heart valve fluid dynamics;
- discussion of the benefits and limitations in using computational fluid dynamics and fluid-structure interaction to investigate the cardiovascular system;
- discussion of the technical challenges that simulating the cardiovascular system presents;
- current findings from our studies on computational methods in investigating the cardiovascular system and its fluid dynamics.

Brief Biography of the Speaker: Daniel is currently a Research Fellow at the University of Birmingham, funded by an Intra-European Personal Fellowship. Over the last 10 years he has developed his research experience in Bio-medical Engineering through computational simulation and mechanical testing of biological tissues of the body. Recently, this has included investigating articular cartilage and its involvement in knee joint mechanics. He obtained his PhD in Bio-Engineering at the University of Aberdeen. Following his PhD, he was awarded a Junior Fellowship by the British Heart Foundation which he held at the School of Mechanical Engineering, University of Birmingham. He has since developed his expertise outside the UK, as a Research Fellow at both the School of Engineering, University of Auckland (New Zealand) and the Medical Technology Laboratory, Istituto Ortopedico Rizzoli in Bologna (Italy).
He has been invited to present his research in the Czech Republic, Greece, Switzerland and the UK. He has served on the conference committee for the International Conference of Systems Biology and Bioengineering and the 2nd Workshop on 3D Physiological Human. He has also been invited to the editorial boards for the International Journal of Engineering & Technology, International Journal of Biological Engineering, Open Journal of Orthopedics, and the Journal of Clinical Rehabilitative Tissue Engineering Research.

Plenary Lecture 6

Modeling for Refrigerant Characteristics in Non-Adiabatic Capillary Tube and Application to Vapor Compression Refrigeration Cycle Analysis

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Abstract: Most modern refrigerators incorporate heat transfer between the refrigerant in a capillary tube and the refrigerant in a suction line. This heat transfer is achieved by a non-adiabatic capillary tube called a capillary tube-suction line heat exchanger (CT-SLHX) and is supposed to improve the performance of the small vapor compression refrigeration cycle by removing some enthalpy of the refrigerant at the evaporator entrance. The thermodynamic properties of the refrigerant in the capillary tube and suction pipe are influenced by associated phenomena. A mechanistic model was developed for the analysis of the non-adiabatic capillary tube based on evaluation of various constituting correlations. This non-adiabatic capillary tube model is based on a homogeneous two-phase flow model. To investigate the effects of this CT-SLHX on the refrigeration cycle, a computer program was developed based on conservation equations of mass, momentum, and energy. The simulation results show that both the location and length of the heat exchange section influence the coefficient of performance (COP) as well as the cooling capacity. It is noteworthy that the influence was not monotonic; that is, the performance may be deteriorated under certain conditions.

Brief Biography of the Speaker: Prof. Ji Hwan Jeong graduated from the Seoul National University, Korea in 1988 and received his Ph.D. from the KAIST (Korean Advanced Institute of Science and Technology) in 1995. He did his post-doctoral research in the Technology Centre in Aerodynamics and Heat Transfer at Oxford University. After three years of research experience at KAERI (Korea Atomic Energy Research Institute), he joined the Faculty of the School of Mechanical Engineering at Pusan National University. He is author of about 80 papers published in international journals and conference proceedings, and invited book chapters. His research interests include multi-phase flow, heat transfer augmentation, heat exchangers, heat pump, and nuclear power plant safety analysis. He has also consulted in the nuclear and air conditioner industries.
He is currently a board member of the SAREK (The Society of Air-Conditioning and Refrigerating Engineers of Korea) and serves as editor of ‘International Journal of Air-conditioning and Refrigeration’ and ‘Journal of Mechanical Science and Technology’.

Authors Index

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