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ABOUT ROORKEE

Roorkee is located at the foothills of Himalayas in the Uttarakhand State. The Railway Station is on the main line of Northern Railways having direct links to Delhi, Mumbai, Calcutta, Amritsar, Jodhpur and Ganganagar. The place is also within easy reach from Delhi, by road (180 km) and is located on Delhi - Haridwar and Delhi - Dehradun bus routes. Roorkee is ideally located near several tourist places like Dehradun (70 km), Mussoorie (100 km), Haridwar (32 km) and Rishikesh (52 km). The temperature varies between 5-10^{o}C in the December end.

DEPTT. OF MECH. AND IND. ENGINEERING

The Department of Mechanical Engineering came into existence in the year 1946 and the first batch of Mechanical Engineers graduated in the year 1949. The department was renamed as Department of Mechanical & Industrial Engineering on its silver jubilee in 1974 when an undergraduate programme in Industrial Engineering was started. At present it offers both undergraduate and postgraduate courses in various facets of Mechanical and Industrial Engineering. The department offers Master of Technology courses in Machine Design Engineering, Production and Industrial Systems Engineering, Thermal System Engineering, Welding Engineering and CAD, CAM and Robotics. The department has laboratory and workshop facilities with modern sophisticated equipment to carry out research in all areas related to Mechanical and Production & Industrial Engineering. The faculties are actively involved in various prestigious sponsored/ consultancy project works from BARC, ARDB, ISRO, DST-FIST, etc.

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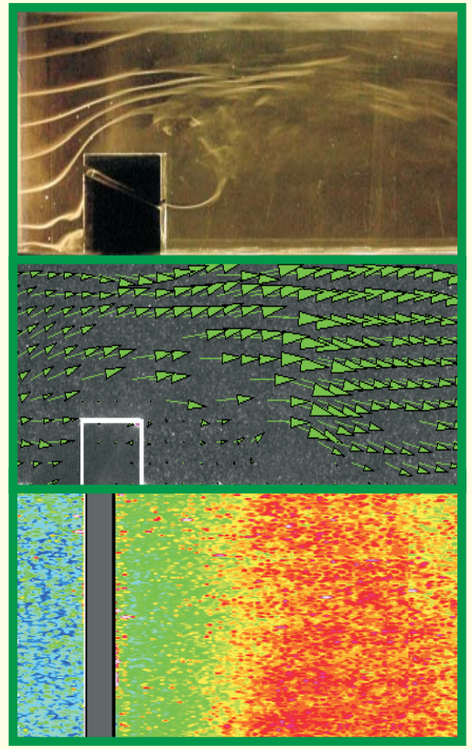
INTERNATIONAL WORKSHOP

on

RECENT TRENDS IN FLOW VISUALIZATION

(December 29-31, 2009)



Flow visualization images and heat transfer pattern over surface mounted rib

Organized by

Department of Mechanical & Industrial Engineering
Indian Institute of Technology Roorkee
Roorkee 247 667 (Uttarakhand)

PROLOGUE

Flow visualization is the art and science of making the physics of fluid flow visible and aims at the discovery, description and parametric investigation of the fluid flow phenomena. Rendering the fluid motion accessible to visual perception can yield invaluable qualitative as well as quantitative information about the complex flow and might be capable of giving information of both global and local behaviours.

Starting from the famous sketch depicting free water jet in the treatise of 15th century genius Leonardo da Vinci, the flow visualization has seen it's major renaissance by Osborne Reynolds' in the cessation of 19th century. Subsequent era had witnessed the variety of optical techniques capturing the beautiful world of flow/thermal patterns.

The insight into a physical process is always improved if the produced pattern can be suitably quantified in terms of various parameters, especially in the context of drag reduction as well as in terms of heat-transfer enhancement. Advent of modern hardware and software capabilities has provided the necessary incentive for acquiring non-intrusive quantitative measurements with some of the state-of-the-art technologies like particle image Velocimetry (PIV), Laser Doppler Velocimetry (LDV), Schlieren imaging, Volumetric 3-component Velocimetry (V3V), liquid crystal thermography (LCT), and Infrared thermography (IR).

Large stride made by computer industries have also continually whetted the appetite of engineers to return to first principles in the case of a turbulent flow and numerically integrate the Navier-Stokes equations through the route of Direct Numerical Simulation (DNS) or Large Eddy Simulation (LES) and RANS in order to solve practical problems of higher and higher complexity.

This workshop is an attempt to provide an overview of the framework of flow visualization and focus on the state-of-the-art techniques in a quest towards understanding flow and heat transfer phenomena.

OBJECTIVES

The objective of the workshop is to provide the state-of-art knowledge of varieties of experimental as well as computational techniques, pertinent in the field of fluid mechanics and heat transfer to persons from academia/industry; and make them familiar with the recent trends in flow visualization in an international perspective.

WORKSHOP STRUCTURE

The workshop will consist of a series of key note and specialized lectures by eminent faculties, and scientists from academia as well as industries. The lectures will be supported by demonstration of available optical techniques like PIV and LCT for flow as well as temperature visualization at aerodynamics and solar energy laboratories, MIED, IIT Roorkee.

COURSE CONTENTS/THEMES

On completion of this module the participants will be able to:

- Understand different experimental and numerical techniques of flow visualization;
- Familiarize with the modern state-of-the-art experimental tools and its application to engineering problems;

Special emphasis will be paid in relation to developing the understanding about principles of PIV and LCT with on-hand laboratory experience.

PARTICIPANTS

Anybody who has paid attention to the patterns while stirring milk into coffee or stared at the curl of a rising tendril of smoke, has participated in flow visualization, and will understand the purpose of this workshop. The course is intended for faculties from engineering institutes, engineers and professionals working in the area of fluid flow and heat transfer across the different branches of engineering. The number of seats is limited to 50 participants. The registration shall be done on the first come first serve basis. Selected participant may be paid TA as per the availability of funds. Each participant will be given a certificate of attending the workshop. Tour for participants is planned to the city Haridwar/ Rishikesh/Mussoorie or Agra on payment basis.

REGISTRATION FEES

The registration fee per participant is as follows:

Sr. No.	Participant category	Registration fee
1	Student	Rs 1,000/-
2	Academic	Rs 2,000/-
3	Industry / SAARC	Rs 5,000/-
4	International	USD 250

The registration fee includes registration kit, course material, refreshment, working lunch and laboratory visit.

The participants are requested to register themselves by filling and mailing the attached registration form latest by 27th November, 2009, along with a demand draft in favour of "The Registrar, IIT Roorkee, IWRTFV-2009 A/c" payable at Roorkee.

SPONSORSHIP

The workshop may be sponsored by institutions, research centres, industries, educational government, autonomous bodies & public sector undertakings and any other interested individual.

Category	Sponsorship fee (Rs.)	Free delegates
Sponsor	100,000.00	4
Co-sponsor	50,000.00	2

The name of sponsoring agency will appear in brochures/proceedings, and will be duly acknowledged and displayed at workshop venue. They will also have the opportunity to display their products/services at workshop venue.

ACCOMMODATION

Accommodation shall be arranged by organizers in the guest houses of IITR, and peripheral organizations like NIH and CBRI etc. on payment basis besides hotels on the request, in advance.

VENUE

The venue of the workshop shall be committee room, Department of Mechanical & Industrial Engineering, IIT Roorkee, Roorkee, Uttrakhand.

REGISTRATION FORM

RECENT TRENDS IN FLOW VISUALIZATION

(December 29-31, 2009)

Name : .....

Designation : .....

Address : .....

.....

.....

Tel. No. : .....

Fax : .....

Email : .....

Qualification : .....

Field of
Specialisation : .....

Experience : .....

Sponsoring Authority : .....

(Signature of Candidate)

SPONSORSHIP CERTIFICATE

Certified that Mr./Ms./Dr. ..... has been officially deputed for the above mentioned workshop to be organised by dept of mechanical and industrial engineering, IIT Roorkee, Roorkee.

Signature of Sponsoring Authority
with Office Seal and Date

(Photocopies of this form can be taken as per the need)

INVITED SPEAKERS*

Dr Mohamed Gad-el-Hak is the **Inez Caudill Eminent Professor** of Biomedical Engineering and chair of mechanical engineering at Virginia Commonwealth University, USA. He received Ph.D. from the Johns Hopkins University, and has since taught and conducted research at the University of Southern California, University of Virginia, University of Notre Dame, Institut National Polytechnique de Grenoble, Université de Poitiers, Friedrich-Alexander-Universität Erlangen-Nürnberg, Technische Universiät München and Technische Universität Berlin. Professor Gad-el-Hak is world renowned for advancing several novel diagnostic tools for turbulent flows, including the laser-induced fluorescence technique for flow visualization; for discovering the efficient mechanism via which the turbulent region grows by destabilizing a surrounding laminar flow and for developing a novel viscous pump suited for microelectromechanical systems (MEMS) applications. Dr Gad-el-Hak holds two patents: for a drag reducing methods for airplanes and underwater vehicles, and for a lift control device for delta wings. Dr Gad-el-Hak has published more than 480 articles; authored/edited 18 books and proceedings. He is the author of the famous book “Flow Control: Passive, Active, and Reactive Flow Management,” and editor of the books “Frontiers in Experimental Fluid Mechanics”, “Advances in Fluid Mechanics Measurements,” “Flow Control: Fundamentals and Practices,” “The MEMS Handbook” (first and second editions), “Transition and Turbulence Control,” and “Large-Scale Disasters: Prediction, Control, and Mitigation.” Professor Gad-el-Hak is a fellow of the American Physical Society, the American Society of Mechanical Engineers, and the American Academy of Mechanics. In 1998, Gad-el-Hak was named as the Fourteenth ASME Freeman Scholar. In 1999, he was awarded the prestigious Alexander von Humboldt Prize, Germany's highest research award for senior U.S. scientists and scholars in all disciplines. In 2002, Gad-el-Hak was named as ASME Distinguished Lecturer, as well as inducted into the Johns Hopkins University Society of Scholars.

Dr S V Ekkad, Associate Professor of Mechanical Engineering, Virginia Tech. USA, He joined the Mechanical Engineering department at Virginia Tech in August 2007 after spending nine years as Associate and Assistant Professor at Louisiana State University and two years as Senior Project Engineer in the Turbines Department at Rolls-Royce Allison Engine Company in Indianapolis. He completed his Ph.D. from Texas A&M University in 1995 and his M.S. from Arizona State University in 1991, both the degrees in the area of turbine cooling and heat transfer. He has over 50 journal publications and 65 conference presentations. He has received over $5.0 million in funding from DARPA, NSF, NASA, Siemens, Pratt & Whitney, GE, Solar Turbines, Toyota, and DOE. He has over 20 years of experience in gas turbine related research working on a variety of problems such as turbine blade tip cooling, film cooling through compound angle holes, internal passages with rib turbulators and bleed holes, impingement cooling arrays, unsteady wake effects on turbine blade heat transfer. He is currently working on Combustor liner cooling with Solar Turbines and innovative cooling configurations with NASA and GE and testing microstructure passage cooling models through funding from NSF. During his two years in the industry, Dr. Ekkad worked on a variety of problems relating to design of hot gas path components. Dr. Ekkad also served as a summer faculty fellow at AFRL, Dayton in 2003. His short tenure at AFRL resulted in two journal papers and two patents. He developed the transient infrared thermography technique at AFRL. In 2004, he was awarded the inaugural ASME Bergles/Rohsenow Young Investigator Award in Heat Transfer for significant contributions to the field of heat transfer, especially in the development of liquid crystal techniques in surface temperature visualization, by a researcher under the age of 36 years.

Dr Jürgen Kompenhans received his doctor´s degree in physics in 1977 from the Georg-August University of Göttingen. Since more than 30 years he is working for DLR in Göttingen, Germany, mainly developing and applying non-intrusive measurement techniques for aerodynamic research. Since 1985 Dr. Kompenhans and his co-workers have developed a mobile Particle Image Velocimetry (PIV) system, which can be operated under the rough environmental conditions of large wind tunnels. This system has been successfully applied in different European flow facilities as well to low speed as to high speed flows.

At present Dr. Kompenhans is head of the Department of Experimental Methods of DLR's Institute of Aerodynamics and Flow Technology in Göttingen. Within this department image based methods such as Pressure Sensitive Paint, Temperature Sensitive Paint, Particle Image Velocimetry (PIV), model deformation measurement techniques, density measurement techniques, acoustic field measurement techniques etc. are developed for application as mobile systems in large industrial wind tunnels and for in-flight testing. Dr. Kompenhans has been responsible as co-ordinator for many projects (national aeronautical research projects, German Research Foundation, EU funded projects, INTAS, industrial contracts). At present he is co-ordinator of the Network of Excellence 'European Windtunnel Association (EWA)'. For more than one decade Dr. Kompenhans was organizer of DLR's annual PIV course. He is Associate Editor of the Journal of Fluids Engineering, co-author of the book 'PIV - a practical guide' and author, coauthor and co-editor of a number of scientific publications on PIV.

* The expert lecture from some eminent scholars from National Aerospace Laboratories (NAL), Bangalore and IIT Madras may also be included.

Dr K Muralidhar, a Ph.D. from University of Delaware, USA has conducted experiments and numerical simulation in applications related to fluid mechanics, heat and mass transfer. He has contributed to the understanding of transport phenomena in porous media, wake dynamics, development of numerical algorithms, and laser measurement of flow and thermal fields. His research finds applications in industrial processes such as enhanced oil recovery, regenerators, nuclear waste disposal, growth of optical crystals and CVD reactors. He was among the earliest to apply a thermal non-equilibrium model for performance Evaluation of regenerators used in cryocoolers. His work on interferometric tomography, fluid-fluid interfaces and schlieren imaging of convection patterns around growing crystals is well-recognized. In this connection, he has addressed the need for iterative techniques to accommodate partial data and incomplete information in measurements. These ideas have been extended to schlieren measurement techniques as well. He has developed algorithms for numerical simulation of multi-phase flow in porous media, oscillatory flows, and inverse techniques for wall heat flux measurement. In the area of wake dynamics, his work shows that three dimensional vortex interactions in nominally two dimensional geometries can be used for flow control. Dr. Muralidhar is the author of one text book, an edited volume and a research monograph. He has contributed a large number of chapters to other texts. He is presently **Professor** of **Mechanical Engineering** and working as the Dean of Research and Development at **IIT Kanpur**.

Dr Pradipta K Panigrahi received his B.Tech. degree with honors in mechanical engineering from University College of Engineering, Burla, Orissa, India, the M.S. degree in mechanical engineering and computer science engineering from Louisiana State University, USA and his Ph.D. degree in mechanical engineering from Louisiana State University, USA. He received the *Swarna Jayanti* fellowship from Department of Science and Technology, Govt. of India in 2006. He has also received the Humboldt fellowship, Germany in 2004, Boyscast fellowship of DST to Japan in 2000 and Career award from AICTE in 1998. His research interests include optical measurement techniques, microscopic engineering, heat transfer enhancement, soft computing, turbulence, _Fluidics, and CAD of thermal system. He is presently **Professor** of Mechanical Engineering at **IIT Kanpur**.

Dr Sanjay Mittal is a **Professor** in the department of aerospace engineering at Indian Institute of Technology, Kanpur. After doing his B.Tech from IIT Kanpur in 1988, he got enrolled at University of Minnesota for M.S program and subsequently did his Ph.D. and worked as a research associate under Prof. Tezduyar. After working for 2 years at Army High Performance Computing Research Center he returned to India and joined IIT Kanpur in the year of 1994. He was also a senior researcher at the Xerox Palo Alto Research Centre, where his research on Artificial Intelligence was greatly acclaimed. As recognition of his research activities he has received various awards such as the Swaranajayanti Fellowship from DST, AK Bose award from INSA, INAE Young Engineer Award and INSA Young Scientist Medal. He has also worked at Chuo University and Rice University as visiting fellow and has been associated with DWO Associates as consultant. He has over a decade of research experience in Computational Fluid Dynamics. He has worked on large scale computations of compressible and incompressible unsteady flows including those that involve moving boundaries and domains. His research areas include Aerospace Engineering, Computational Fluid Dynamics, Finite Element Methods, Parallel Computing, Flow-induced oscillations. Presently, he also works as the Dean of Academic Affairs at **IIT Kanpur**.

Dr B K Gandhi received BE in mechanical engineering from SGSITS Indore and thereafter completed MTech from **IIT, Bombay** and PhD from **IIT, Delhi**. He is working in the area of experimental fluid mechanics and his special interest includes rotodynamic machines. He is also working on heat transfer enhancement, erosion wear and computational fluid dynamics. He visited Nagoya University, Japan for post doctoral work under JSPS fellowship and presently working on a joint project with Pfleiderer Institute of Turbomachinery, Germany. He is actively involved and successfully completed many sponsored research and consultancy projects. He is one among the pioneer in starting the optical measurement facility for flow control at Aerodynamics and Solar Energy Laboratories, IIT Roorkee, and his present research includes application of stereoscopic PIV system for turbulent flow measurement. He is presently **Professor** of **Mechanical & Industrial Engineering Department** at **IIT Roorkee** and the co-coordinator of Centre for Continuing Education and QIP at IIT Roorkee.

Dr Andallib Tariq received his BE in mechanical engineering from Bangalore University and earned M.Tech and PhD from IIT Kanpur. He visited at College of Engineering, Qassim University, Saudi Arabia for three years as an Assistant Professor and subsequently joined **IIT Roorkee**, as **Assistant Professor** in Mechanical & Industrial Engineering Department. He has established and implemented a critical heat transfer enhancement technology based on *liquid crystal thermography* (LCT). His research interest includes: Experimental fluid mechanics, Turbulence, Optical based flow diagnostic tools, Flow visualization, Heat transfer enhancement and Gas turbine blade cooling. He is well acquainted with flow measurement techniques like Hotwire anemometry, LCT, PIV, along with high response micro-pressure sensors, and piezoelectric actuators. His expertise extends to image-processing, pattern recognition methods, and Fast Fourier Transformation (FFT) technique for image/turbulence analysis. Presently he is working towards the application of Proper Orthogonal Decomposition technique on the PIV data in order to capture the complex flow features of turbulent flow and designing an innovative optical approach towards measuring the thermal contact conductance at the interface.