International Workshop on Sustainable Energy, Power and Propulsion

March 18-22, 2018

Organized By

National Institute of Technology Kurukshetra, India
and
Terminal Ballistics Research Laboratory Chandigarh, India

Collaborators/Sponsors

Foreword...

Dr. Satish Kumar

Director, NIT Kurukshetra

In my professional career which spans over three and half decades, I was associated with the aerospace industry for a significant period in the field of missiles, strategic systems and hypersonic propulsion. Power and propulsion play a very important role in the fields of aviation, defense etc. and there is a pressing need to amalgamate these areas with the discipline of sustainable energy to produce technology which is clean and green, which would equally serve the present needs and tend to the future requirements where the conventional sources of energy may be extinct. I say it with extreme pride that the National Institute of Technology (NIT) Kurukshetra and Terminal Ballistic Research Laboratory (TBRL) Chandigarh, are jointly organizing an **International Workshop on Sustainable Energy, Power and Propulsion (ISEPP-2018)** which is 9th in a series of workshops on the broad theme of Energy, Power and Propulsion that started in 2004. Over the years, this workshop grew into a world class forum enquiring into the status of sustainable developments in Power and Propulsion. This iteration of the workshop is in collaboration with Indian Institute of Technology (IIT) Kanpur, University of Maryland, College Park, University of Illinois at Chicago, Analytic & Computational Research Inc. USA. The focal point of this workshop lies at the general theme of **Clean Energy Production & Utilization.** Over 150 distinguished delegates from all over the globe have been invited to give their contributions in the fields of Propulsion, Pulse Detonation, Environmental Sustainability, Combustion, Emissions etc. to name a few. A paper presentation competition for students is also being organized to bring the young talent into limelight. This attempt at the sustainable developments in the areas of power and propulsion is definitely one of its kind. I wish everyone associated with this workshop a very good luck and I am very confident that at the end of this workshop, we all will have moved a step closer to a clean and sustainable future.

Thank You
Satish Kumar

Dr. V K Saraswat

Member, NITI Aayog, Government of India

Dr. Vijay Kumar Saraswat, is a scientist of international renown and an accomplished researcher with more than four decades of experience spanning over several areas in both basic and applied sciences of defence research. He is a rare combination of an innovator, technologist and visionary.

Born at Gwalior on 25 May 1949, Dr Saraswat completed his engineering from Gwalior; Master of Engineering from IISc Bangalore followed by Ph.D from Osmania University. During his illustrious career, he held the twin posts of Scientific Adviser to Defence Minister and Director General DRDO & Secretary to Dept of Defence R&D. He served as Project Director Prithvi Missile and Programme Director, Ballistic Missile Development (BMD) Programme under the Integrated Guided Missile Development Program. In addition, Dr. Saraswat did pioneering work in the indigenous development of the cutting-edge technologies such as Successful test firing of **AGNI-5,** Initial Operational Clearance for Light Combat Aircraft TEJAS and Induction of INS Arihant, etc. Dr. Saraswat's pioneering efforts have taken shape into setting up of the establishments like Research & Innovation Centre at **IIT Madras, MILIT Centre** for Training needs of armed forces on S&T, etc.

Till recently, Dr Saraswat was DAE Homi Bhabha Chair and initiated development of technologies for **Energy Security** in the country at various Industrial and Academic Institutions in addition to bringing new dimensions to **Aerospace Manufacturing.** Dr. Saraswat is the recipient of many national and international awards including PADMABHUSHAN (2013) and PADMASHRI (1998). He is a Fellow / Member of a number of Professional Bodies, including the Aeronautical Society of India and the Combustion Institute (India Section).

Honoris Causa was conferred upon him by more than 25 Universities including Andhra University (Visakhapatnam), NIT Surat, NIT Kurukshetra, ISER Bhopal, JNTU Hyderabad, Abdul Kalam Technical University Lucknow etc. He has also authored and presented several papers for at National & International level journals / conferences and guided eight Ph.D Scholars. He is leading the "Methanol Economy Mission" to meet India's requirement of Alternative fuel for energy and transportation thereby reducing our crude oil imports. Dr. Saraswat presently is the **Member NITI Aayog and Chancellor of the prestigious Jawaharlal Nehru University** and shouldering many Honorary positions in Government and Academic Institutions.

Dr. S K Salwan

Chairman,
Armament Research Board
DRDO

Dr. Salwan is Expert of Strategic Defence and Defence Technologies. He has been Director of three National Level Laboratories and Establishment of Defence Research. He has been Advisor (Strategic Projects) of DRDO Ministry of Defence. He was appointed as Emeritus Scientist DRDO in 2003. Dr. Salwan was Vice Chancellor Punjab Technical University Jalandhar (2003-2008) and Founder Vice Chancellor Apeejay Stya University (2008-2011). He held DRDO Nagchowdhary Chair Distinguished Professor and DRDO Fellow. (2011-2013).

He is Chairman Armament Research Board and Chairman Research Council ARDE Pune. Dr. Salwan is member of Advisory Group of Experts, Ministry of Railways, Railway Board and member of Board of Governors of many Universities in India and Abroad. Dr. Salwan is member of 'Make in India', NITI Aayog, Govt. of India.

He has been founder member of Integrate Guided Missiles Programme of Defence Research under the leadership of Dr. APJ Abdul Kalam.

Dr. Salwan is recipient of many National and International Awards. Dr. Salwan was awarded Scientist of the year (engineering) in 1992. He was awarded Panj Pani award by Prashar Bharti for his outstanding contribution to Science & Technology in 2004 and Punjab Ratana in 2007. He was awarded Life Time Achievement Award by Defence Research & Development Organization for Invaluable Contribution in Defence Technologies and Strategic Defence - 2009. Dr. Salwan was awarded "India's Eminent Vice Chancellor Award '2016" by All India Council of Human Rights, Liberties & Social Justice in 2016.

18 students have been awarded Ph.D degree under the guidance of Dr. Salwan. Dr. Salwan has published more than 35 papers in International Journals of high impact value. He has published more than 45 papers in Indian Journals of impact value. He has given more than 40 invited talks in India, Australia, Singapore, Netherland & Sweeden.

At present Dr. Salwan is the Vice Chancellor of Apeejay Stya University and Chief Executive Officer (Higher Education) of Apeejay Education Society.

Mr. V K Raizada

Executive Director,
IOCL (Panipat Refinery)

Mr. V. K. Raizada is holding, wef November 21, 2017, the charge of Executive Director of Indian Oil's Panipat Refinery & Petrochemical Complex (PRPC), the largest integrated Refinery Complex of its kind in the country .

Prior to taking over charge of Executive Director, PRPC, Mr. Raizada was working as Executive Director (Technical), Panipat Refinery, overseeing all technical aspects of day to day working of the Mega Refinery.

An Electrical Engineer from the Delhi College of Engineering, supplemented with a Senior Management Training from IMI, Delhi and Europe, Mr. Raizada has over three decades of experience to his credit in the national and international Hydrocarbon Industry.

After joining Indian Oil in 1984 as a Graduate Engineer Trainee, he has worked in different areas of operations, maintenance and projects in various capacities at Indian Oil's Mathura Refinery in Uttar Pradesh, Panipat Refinery, Haryana and at the Refinery Headquarters, New Delhi.

Dr. Manjit Singh

Director,
TBRL Chandigarh

Dr. Manjit Singh is a renowned science and technology expert in the field of detonics of high explosives and dynamic shock compression of the materials under multi Mbar pressure regime. He is a physicist and completed his M.Sc, M.Phil and Ph.D in Physics from Punjab University, Chandigarh. In DRDO, he has contributed to the field of Shock Wave Physics especially in development of various explosive systems.

He played a lead role in creating state-of-the art experimental facilities consisting of Powder Gun, Two Stage Light Gas Gun, Split Hopkinson Presure Bar (SHPB), Ultra-high Speed Photography, Ballistic Test Facility, Penta Rail Supersonic Track etc., which has made TBRL a unique centre where the projectile can be launched to valicities from 300 to 8500 m/s under one roof with a time resolution of up to 5 nano second.

He joined TBRL as Director on 29th July, 2011 and has been leading it in development of warhead systems, establishing world class test and evaluation facilities and explosive processing facilities. Under his leadership the laboratory has expanded its R&D base into new areas like Tactical Missile Warheads, Fuze Technologies, High Power Micro-wave systems etc. He has published more than 80 papers in national and international journals and conferences.

For his contributions in defence R&D he received Commendations and Cash Award by Hon'ble Prime Minister of India in 1998 for his contribution in Shakti'98, Technology Award by Scientific Adviser to Defence Minister in the year 2001 for his contributions in detonics and shock dynamics, Scientist of the Year Award from Hon'ble Prime Minister of India in 2009, Special award for strategic contribution in 2012 by Hon'ble Defence Minister of India for development of Plastic Bonded Explosives to name a few.

He is also the Chairman, High Energy Materials Society of India (HEMSI), Chandigarh-Delhi Chapter and an active member of Governing Council Institute of Plasma Research Gandhinagar, ITER-India Empowerd Board, Aeronautical Society of India and the Armament Research Board of India among many.

Schedule

March 18, 2018		
Event	**Time**	**Details**
Registration Venue: Senate Hall	09:00-10:30	Welcome tea and registration
Session-1: Advanced Propulsion Venue: Senate Hall	10:30-11:15	Recent developments in the research on pressure gain combustion devices **Kazhikathra Kailasanath**
	11:15-12:00	Anatomy of rotating detonation engines **Kenneth Yu**
Tea Break	12:00-12:30	Senate Hall
Session-2: Fundamental Combustion Venue: Senate Hall	12:30-13:15	Hypersonic flow – a high Mach number, high enthalpy flow, an overview **Ibrahim Sugarno**
	13:15-14:00	Laminar burning speeds of propane/co_2/air mixtures at high temperatures and pressures **Hameed Metghalchi**
Lunch Break	14:00-15:00	NIT Kurukshetra Guest House
Session-3: Combustion Analysis Venue: Senate Hall	15:00-15:45	Lean domes' operability challenges: non-reacting flow characteristics of 60° CW/ 60° CCW LDI configuration **Hukam Mongia**
	15:45-16:30	Novel findings in unsteady behavior of syngas combustion as an alternate clean energy source **S. R. Chakravarthy**
Tea Break	16:30-17:00	Senate Hall
Session-4: Steam Gasification Venue: Senate Hall	17:00-17:35	Synergistic effects in steam gasification of biomass and plastic waste mixtures **Ashwani K. Gupta**
Inauguration Venue: Jubilee Hall	18:00-19:30	**Inaugural Session**
Welcome Dinner	19:30 Onwards	Institute Guest House

March 19, 2018		
Event	**Time**	**Details**
Session-5: Gas Turbine Combustion Venue: Senate Hall	9:30-10:15	External enthalpy -controlled fuel lean and rich premixed combustion **Peter Lindstedt**
	10:15-11:00	Early detection and control of lean blowout in gas turbine combustors **Achintya Mukhopadhyay**
Tea break	11:00-11:30	Senate Hall
Session-6: Computational Methods for the Energy Venue: Senate Hall	11:30-12:15	Combustion characteristics of biomass-based fuels for engine applications **Amitava Datta**
	12:15-13:00	Computational-analytical methods in the hybrid solution of energy problems **Renato M Cotta**
Lunch Break	13:00-14:00	NIT Kurukshetra Guest House

Schedule

Session-7: Experimental Heat Transfer Venue: Senate Hall	14:00 14:45	JAXA's activity on alternative jet fuels and combustion experiments using combustors for aero-engines **Keiichi Okai**
	14:45-15:30	Smart and adaptive structured heat exchangers: functionality and substantiality **Rachid Bennacer**
Tea break	15:30-16:00	Senate Hall
Poster Presentations Venue: Senate Hall	16:00-17:30	Poster presentations
Cultural Program Venue: Jubilee Hall	18:00-19:30	Cultural program
Gala Workshop Dinner @ Hotel Riyasat Resort, 152 KM Stone, NH1, Samani, Kurukshetra, 19:30 Onwards		

March 20, 2018		
Event	**Time**	**Details**
Session-8: Atomization and Sprays Venue: Senate Hall	9:30-10:15	How a spray interacts with swirling flow **Saptarshi Basu**
	10:15:11:00	Investigation of two-phase flow and liquid breakup behavior in gas flow field **Ryo Amano**
Tea break	11:00-11:30	Senate Hall
Session-9: Heat and Mass Transfer Venue: Senate Hall	11:30-12:15	Turbulent flow, heat and mass transfer in permeable media **Marcelo de Lemos**
	12:15-13:00	Heat and mass transfer on the bulk of doctor engineer debate **M. El Ganaoui**
Lunch Break	13:00-14:00	NIT Kurukshetra Guest House
Session-10: Energy Venue: Senate Hall	14:00-14:45	Residual biomass resources: An invaluable reservoir of energy and matter **Biagio Morrone**
	14:45-15:30	Small sc ale transport phenomena for energy-water-food-environment nexus **Manish Tiwari**
Tea break	15:30-16:00	Senate Hall
Session-11: CFD Solutions Venue: Senate Hall	16:00-16:45	Will RANS survive LES: A perspective in energy and environmental engineering **Kemal Hanjalic**
	16:45-17:30	Application of CFD methods in aerospace propulsion design **Debasis Chakraborty**

Schedule

March 21, 2018		
Event	**Time**	**Details**
Session-12: CFD Venue: Senate Hall	9:00-10:45	CFD-An overview for Engineering Colleges **Madhukar Rao**
Tea Break	10:45-11:00	Senate Hall
Session-13: Sustainable Cooling Technology Venue: Senate Hall	11:00-11:45	Development of advanced cooling technologies for sustainable future **Yunho Hwang**
Session-14: Fuel from waste Venue: Senate Hall	11:45-12:30	High quality solid fuels from wastes and biomass **Kunio Yoshikawa**
Tea Break	12:30 -12:45	Senate Hall
Session-15: Sustainable Biofuels Venue: Senate Hall	12:45 -13:30	Conventional propulsion fuels to sustainable biofuels - the road ahead **Gabriel D. Roy**
Lunch break	13:30-14:30	NIT Kurukshetra Guest House
Session-16: Alternate Fuels Venue: Senate Hall	14:30-15:15	Next generation biofuels – opportunities and challenges for India **Naveen Kumar**
	15:15-16:00	Hydrogen as electricity storage **Jens Klingmann**
Tea Break	16:00-16:30	Senate Hall
Session-17: Bio Fuels Venue: Senate Hall	16:30-17:15	Green and clean energy recovery from old landfill dumpsite for sustainable development **Somrat Kerdsuwan**
Session-18: Scientific Writing Venue: Senate Hall	17:15-18:15	Scientific writing skills **Akash Chakraborty**

March 22, 2018		
Event	**Time**	**Details**
Session-19: Solar PV Venue: Senate Hall	9:30-10:30	PV trend and high efficiency PV technologies **Ray Y. Lin**
Session-20: Soot Reduction Venue: Senate Hall	10:30-11:00	On soot reduction using oxygenated combustion **Suresh K. Aggarwal**
Tea break	11:00-11:30	Senate Hall
Session-21: Bio Gasifier Venue: Senate Hall	11:30-12:30	Feasibility study on integration of beta-type stirling engine-generator and wood pellet gasifier **Sutapat Kwankaomeng**
Session-22: CFD Application in HVAC Venue: Senate Hall	12:30-13:00	Energy efficiency via modeling of airflow, thermal comfort and particle transport in hospital ventilation systems **Akshai K. Runchal**
Valedictory	**13:00 -14:00**	**Venue: Senate Hall**
Lunch Break	14:00 Onwards	NIT Kurukshetra Guest House

List of Distinguished Speakers

1. **Kazhikathra Kailasanath,** Naval Research Laboratory, USA
2. **Kenneth Yu,** University of Maryland, USA
3. **Mohammed Ibrahim Sugarno,** Indian Institute of Technology Kanpur, India
4. **Hameed Metghalchi,** Northeastern University, USA
5. **Hukam Mongia,** CSTI Associates, USA
6. **S.R. Chakravarthy,** Indian Institute of Technology Madras, India
7. **Ashwani K. Gupta,** University of Maryland, USA
8. **Peter Lindstedt,** Imperial College London, UK
9. **Achintya Mukhopadhyay,** Jadavpur University Kolkata, India
10. **Amitava Datta,** Jadavpur University Kolkata, India
11. **Renato Machado Cotta,** National Commission of Nuclear Energy, Brazil
12. **Keiichi Okai,** Japan Aerospace Exploration Agency, Japan
13. **Rachid Bennacer,** University of Cergy-Pontoise, Paris, France
14. **Saptarshi Basu,** Indian Institute of Science, India
15. **Ryo S. Amano,** University of Wisconsin-Milwaukee, USA
16. **Marcelo de Lemos,** Instituto Tecnologico de Aeronautica, Brazil
17. **Mohammed El Ganaoui,** University of Lorraine, France
18. **Biagio Morrone,** Universita' Degli Studi Della Campania, Italy
19. **Manish K. Tiwari,** University College London, UK
20. **Kemal Hanjalic,** Delft University of Technology, Netherlands
21. **Debasis Chakraborty,** DRDL, India
22. **Yunho Hwang,** University of Maryland, USA
23. **Kunio Yoshikawa,** Tokyo Institute of Technology, Japan
24. **Gabriel D. Roy,** CPnE Consultants, USA
25. **Naveen Kumar,** DTU, India
26. **Jens Klingmann,** Lund University, Sweden
27. **Somrat Kerdsuwan,** King Mongkut's University of Technology, Thailand
28. **Ray Lin,** TaiCrystal Int. Technology Co. Ltd., Taiwan
29. **Sutapat Kwankaomeng,** King Mongkut's Institute of Technology, Thailand
30. **Suresh K. Aggarwal,** University of Illinois at Chicago
31. **Akshai Runchal,** ACRi, USA
32. **Abhijit Kushari,** IIT Kanpur, India
33. **Ashoke De,** IIT Kanpur, India
34. **Madhukar Rao,** ACRi, USA
35. **Akash Chakravorty,** Springer Nature

Kazhikathra Kailasanath

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Dr. Kailasanath recently retired as the Director of the Laboratories for Computational Physics and Fluid Dynamics at the Naval Research Laboratory. He received his Ph. D from the Georgia Institute of Technology in 1980 and was at the Naval Research Laboratory from then to 2017. Prior to that, he received his M.S.A.E. from the Georgia Institute of Technology in 1979 and his B. Tech in Aeronautical Engineering from the Indian Institute of Technology (Madras) in 1976. His research interests include the structure, stability and dynamics of flames and detonations; combustion instabilities in ramjets; multiphase flows; subsonic and supersonic mixing and noise generation; and the simulation of advanced propulsion system concepts. He has published over 400 articles on these topics. He is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), the American Physical Society (APS) and The Institute of Physics (U.K.). He received a Department of Navy Meritorious Civilian Service Award in 2009, a Delores Yetter Top Navy Scientist/Engineer of the Year Award in 2011 and the Captain Robert Conrad Dexter Award for Scientific Achievement in 2014. He has also received the U.S. Navy's Alan Berman Research Publication Award in 1983, 1992, 1994, 2000, 2004, 2009, 2011 and 2015.

Abstract

Recent Developments in the Research on Pressure Gain Combustion Devices

The concepts for using detonations and other pressure-gain combustion processes for propulsion and other applications have been around for more than sixty years. However, it is only in the last couple of decades that the true potential for propulsion and power has been fully explored and demonstrated. Since the mid 1990's, detonation based propulsion concepts have received serious consideration as a means to achieve a revolutionary advancement in the performance of engines for air-breathing and rocket propulsion. The basic theory, design concepts and the work in the last two decades related to pulse detonation engines has been discussed by several researchers. Reviews of specific aspects such as performance estimates and nozzles for pulse detonation combustion systems have also been presented. A comprehensive description of the challenges involved and the status then was published in 2004. More recent updates on the status are also available . The primary focus of these studies in the past decade has been on the "pulsed" detonation engine (PDE) concept. While the PDE concept has matured significantly, there is the potential to increase further the substantial performance gains made by the PDE concept over the traditional constant-pressure cycle based propulsion engines by moving from "pulsed" or "intermittent" detonations to a more "continuous" mode of operation with detonations. In this presentation after a brief overview of the current Worldwide research activities on using detonations for propulsion and power, recent developments will be discussed in the broader context of pressure-gain combustion, which may be achieved with or without "detonations".

Kenneth H. Yu

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Professor Ken Yu has been teaching at the University of Maryland, College Park, Maryland, USA since 1999. His research interests are in the general areas of propulsion, combustion, and hypersonics. Some of his pioneering research contributions include the work on liquid-fueled active combustion control, cavity-based supersonic mixing enhancement, and convective-acoustic combustion instability. He has advised 11 Ph.D. and 22 M.S. theses in those areas. His work has resulted in over 200 publications in technical journals, books and conferences, as well as producing nine U.S. patents and four conference best paper awards. He received all his academic degrees from the University of California at Berkeley, including his Ph.D. in Mechanical Engineering in 1989. Before joining the faculty in Maryland, he worked as a Physical Scientist at Naval Air Warfare Center in China Lake, California for about ten years. He currently directs the University of Maryland Hypersonic Center of Testing Excellence as well as the Advanced Propulsion Research Lab. He is a fellow of American Society of Mechanical Engineers (ASME).

Abstract

Anatomy of Rotating Detonation Engines

Jet propulsion technology based on the Brayton thermodynamic cycle has matured to the point that continuing investment on research and development (R&D) results in diminishing marginal returns. In contrast, rotating detonation engine (RDE) provides an alternative combustor concept that can potentially revolutionize the future propulsion and power systems. In this talk, various performance considerations will be discussed that made the RDE concept an attractive option for propulsion and power applications. Then, some of RDE research at the University of Maryland will be summarized, including (i) a two-dimensional model development work using the method of characteristics (MOC) technique, and (ii) an experimental study visualizing the fundamental structure of unwrapped RDE flowfield. The 2-D MOC approach provides a numerically efficient model that may be suitable for large parametric studies for design optimization and performance estimation. For experimental study, fundamental behavior of detonation wave propagating across an array of reactant jets inside a linear open channel was investigated. Various propellant combinations, including hydrogen-air, hydrogen-oxygen, ethylene-air, and ethylene-oxygen, have been tested in this experimental setup to provide better understanding of incomplete mixing and partial confinement effects.

Mohammed Ibrahim. S

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Assistant Professor, Department of Aerospace Engineering, Indian Institute of Technology, Kanpur, India.

B. E. Aeronautical Engineering, Park College of Engineering & Technology, Anna University, Chennai, India

Ph. D, Aerospace Engineering, Indian Institute of Science, Bangalore, India

Field of Interest: Experimental Hypersonic Aerodynamics, Shock Waves

Abstract

Hypersonic Flow - A High Mach Number, High Enthalpy Flow, An Overview

With the advancement in aerodynamics and propulsion we have successfully devised techniques to break the so called sound barrier and travel faster than speed of sound. The first successful manned supersonic flight of Bell X-1, led to several research and development activities on supersonic ($M > 1$) flight back in 1950's. The advancement in rocket technology further contributed to this field enabling us to push flight speed greater than Mach 5, where we enter a new flight regime called hypersonic. Although, this hypersonic flight regime has been studied for the last five decades, still there remain a lot of unsolved problems due to the complexity of the flow-field. In this talk some of the challenges involved in simulating and studying a hypersonic flow-field shall be presented with emphasis on ground testing/experimental techniques.

Mohammad Metghalchi

Northeastern University, USA

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Mohamad (Hameed) Metghalchi received Bachelor of Science in Mechanical Engineering from Oklahoma University. He received Masters and Doctor of Science in Mechanical Engineering from Massachusetts Institute of Technology. He joined department of Mechanical Engineering at Northeastern University in Fall of 1979. Prof. Metghalchi served as the Chair of Mechanical and Industrial Engineering Department from 2004 to 2012. He has also served as Senior Associate Dean and Interim Dean of College of Engineering in 2006-07. He is currently Director of Master of Science program in Energy Systems Engineering. Professor Metghalchi is an active member of national professional societies such as American Society of Mechanical Engineers, American Society of Engineering Education, Society of Automotive Engineers and Combustion Institute. He is Fellow of ASME and past chair of the Executive Committee of the Advanced Energy Systems Division of ASME. He is the Editor-in-Chief of ASME Journal of Energy Resources Technology. He is recipient of 2011 ASME Harry Potter Gold Medal of Thermodynamics and 2014 ASME Edward Obert Award for thermodynamics. He has been proposal and scientific paper reviewer for National Science Foundation, Army Research office, Combustion Science Technology, Combustion Institute, ASME Journal of Energy Resources technology, ASME Journal of Engineering for Gas Turbine and Power, Combustion and Flame, Biotechnology and American Chemical Society.

Professor Metghalchi's research is in the general area of Thermofluids dealing with scientific issues in power, energy, combustion, fluid mechanics, thermodynamics and chemical reactions. His research has been funded by National Science Foundation, Army Research office, Office of Naval Research, Department of Energy, Qatar Foundation and private companies such as Ford Motor Company, Cater Pillar, Stone and Webster Corporation, Integrated Genetics, Genzyme Inc, and Environ International Corporation. Professor Metghalchi has supervised 17 Ph. D. dissertations and 25 M.Sc. thesis at Northeastern University. Currently, five graduate students are working under his supervision. Professor Metghalchi has published extensively in education and research areas in the last thirty years.

Abstract

Laminar Burning Speeds of Propane/CO2/Air Mixtures at High Temperatures and Pressures

The blends of propane (C_3H_8) and carbon dioxide (CO_2) were considered as alternative natural refrigerants. The laminar burning speeds (LBS) of spherically expanding flames of propane (C_3H_8) and carbon dioxide (CO_2) mixtures with air were measured experimentally for a range of equivalence ratios (from 0.7 to 1.2), temperatures (from 298 K to 620 K), pressures (from 1 atm to 6.2 atm), and CO_2 concentrations (from 0% to 60%). Experiments were conducted using a cylindrical chamber to study the flame structures and a spherical chamber to measure laminar burning speeds. The cylindrical chamber was set up in a Z-shape Schlieren system coupled with a high-speed CMOS camera that was used to capture evolutionary behavior of flames at speeds up to 40,000 frames per second. Only flames that were completely laminar, smooth, and spherical were used to calculate the laminar burning speed. Pressure rise as a function of time during the flame propagation in the spherical vessel was the primary input to the multi-shell thermodynamic model used to calculate the laminar burning speed. Experimental burning speed results were compared with simulation values obtained by the solution of one dimensional steady premixed flame code from CANTERA using published chemical kinetics mechanisms. Comparisons show very good agreement with the available experimental data in this study. Laminar burning speed was observed to decrease with increasing the dilution of propane with CO_2. Laminar burning speed results were calculated for various mole fraction mixtures to determine the appropriate proportions which have low burning speeds. Thus, those mixtures can be classified as low-flammability refrigerants.

Hukam Mongia

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Dr. Mongia continues to provide services in gas turbine combustion science and technology innovation since May 2011. During his 7-year stay at Purdue University, Dr. Mongia collaborated with his colleagues and students on research activities relevant to next-generation energy efficient fuel-flexible ultra-low emissions gas turbine engines for propulsion and power generation. These included collaborative works with IISc, IITM, UCONN/HAPRI-ACAE, Spectral Energies, NASA, Woodward, Nexus, FAA/UT and Dresser Rand. During his 37-year career with three engine design and manufacturing companies (GE Aviation, Allison, now Rolls Royce of North America, and Garrett, now Honeywell Aerospace), he has contributed significantly in developing combustion technology, design methodology and tools in addition to transition of technology into products; e.g., TAPS for GEnx, LEAP-X, GE9X and other future GE propulsion and aeroderivative industrial engines. Dr. Mongia with PhD, MSME, University of Massachusetts (1971, 1969); BSAE, Punjab Eng. College (1965), and Fellow of ASME and AIAA has been given many recognition awards including AIAA Air Breathing Propulsion Award (2008) and Propellant and Combustion Award (1997), GE awards: Edison (2003) and Perry T. Egbert Jr. (2003), NASA's "Turning Goals into Reality" in 2000, and "125 Alumni to Watch" at the UMASS 125th Anniversary Celebration, 1988.

Abstract

Lean Domes' Operability Challenges: Nonreacting Flow Characteristics of 60° CW/ 60° CCW LDI Configurations

Several lean-dome combustion concepts including lean direct injection (LDI) are being pursued for potential applications in low emission propulsion engine combustion systems. Engineering experiments backed by diagnostics and CFD simulations of lean-dome relevant pilot combustor devices are being conducted in a single element combustor test rig. Measurements of non-reacting and reacting flow field and flame characteristics as function of overall fuel/air ratio are carried out by using time-resolved particle image velocimetry (TR-PIV), OH* chemiluminescence, and high-speed visual photographs. The simulations are carried out by the commercial computational fluid dynamics (CFD) software Fluent. Grid adaptions based on gradient of velocity magnitude have been undertaken to achieve grid independence. The Reynolds-averaged Navier-Stokes (RANS), and pure large eddy simulation (LES) are investigated for the performances of simulating turbulent swirling flow in current LDI combustor. The embedded large eddy simulation (ELES), as a regional hybrid RANS/LES approach, is also carried out. The standard k-ε (SKE), the realizable k-ε (RKE), and the full Reynolds stress model (RSM) are used for the RANS simulations. The dynamic Smagorinsky-Lilly subgrid model is used in LES regions of the pure LES case and ELES case; whereas RKE is utilized for the RANS regions. The numerical predictions are compared with the nonreacting PIV data for one of the eight configurations investigated. ELES followed by LES give better agreement with data compared to the three RANS models investigated.

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Satya Chakravarthy is a Professor of Aerospace Engineering at the Indian Institute of Technology Madras, Chennai, India.

He received his Bachelor of Technology degree in Aerospace Engineering in 1991 from IIT Madras, and went to obtain his Master of Science in Aerospace Engineering degree in 1992 and Doctor of Philosophy in 1995, both from the Georgia Institute of Technology, Atlanta, GA, USA. After a brief post-doctoral stint at Georgia Tech, he joined the Department of Aerospace Engineering at IIT Madras in 1997, where he was appointed Assistant Professor in 1998, and Associate Professor in 2003. He is serving as Professor there since 2009. In between, he has visited Georgia Tech in 2000-2001, and Technische Universitat Darmstadt in 2002, 2003, 2006, and 2009. Satya Chakravarthy works in the areas of propulsion and combustion, and researches on different aspects of combustion in gas turbine and rocket engines. He heads the National Centre for Combustion Research & Development (NCCRD) at IIT Madras supported by the Department of Science and Technology, Government of India, with a fund of Rs. 47 crore, which is augmented by research funding over Rs. 54 crores with 33 industry projects on different aspects of combustion in automotive, aerospace, thermal power, and fire research. The NCCRD is the largest of its kind in the world, with a 5-storey building that houses the state-of-the-art facilities on combustion research, including a 33 metre-tall microgravity drop tower. Recently, Satya Chakravarthy is also heading the Centre of Propulsion Technology supported by DRDO with funding of Rs. 84 crores. He has nearly 80 peer-reviewed archival journal publications to his credit, and presented over 200 conference papers, delivered many keynote/plenary/invited lectures, visited many universities such as MIT, Cambridge, TU Berlin, TU Munich, etc., and industries such as GE, FM Global, etc. He is on the editorial board of Progress in Energy and Combustion Science, and is a Colloquium Co-Chair on Solid Fuel Combustion for the International Symposium on Combustion, Dublin, 2018. He has been awarded the HAL Prize for the best undergraduate in aerospace engineering in 1991, the Young Engineer Award by the Indian National Academy of Engineering in 2003, the Young Faculty Recognition Award by IIT Madras in 2009, the Dalmi-HEMSI-ACRHEM Award by the High Energy Materials Society of India in 2009, and the DRDO Academic Excellence Award by the Defence Research and Development Organization in 2009 and 2016.

Abstract

Alternative Sources of Thermo-Chemical Conversion

The use of alternative sources of thermo-chemical conversion has the potential to meet the growing demand for energy. One such is synthesis gas or syngas, which is used for powering fuel-flexible gas turbines. Syngas is mainly composed of hydrogen and carbon monoxide but this proportion may vary depend upon its source and process to obtain. This wide range of chemical composition of syngas is very important parameter to be taken into consideration for designing combustor for its stable performance. Understanding the effect of composition of syngas is paramount for steady as well unsteady aspects of combustion viz. flame holding region and combustion instability.

In the present talk, attention is focused on the role of proportion of carbon monoxide to hydrogen that is widely varied to simulate different compositions of synthesis gas in a bluff-body combustor with non-premixed reactants. A stability map, covering a wide parameter space is presented to understand the global behavior of this combustor. The stability behavior is further extended in the spectral space, whereby differences with conventionally employed gaseous fuels like Methane and pure Hydrogen. It is found that syngas displays multiple modes of combustion. A low frequency (fundamental-mode) oscillation is seen to exist at low inlet air velocities, whereas higher modes are excited at higher air flow rates. This is in contrast to the other fuels listed, that have been observed to display single mode dynamics over the span of inlet air flow rates. This finding is novel and seldom explored, and is crucial towards design of combustors, whereby the short combustor lengths can lock to the excited acoustic field, resulting in resonance.

The novel dynamics associated with syngas is further studied for its flame-acoustics interaction by means of high-speed CO*/ CO2* and OH* chemiluminescence imaging, along with dynamic pressure measurement. An image based technique, abbreviated as SIV (Spatial Intensity Variation), is applied to identify possible flow structures that result in high frequency oscillations. Through SIV, it is apparent that, there are two reaction zones (two oscillators, in the context of acoustic oscillations), that distinguish syngas combustion from other fuels. The presence of two reaction zones underscores the role of chemical kinetics, whereby dominant exothermic reactions happen at different rates resulting in the observed behavior. Further, the flame-acoustic oscillations along-with high speed PIV diagnostics, identifies the role of shear layer vortices in sustaining the high frequency oscillations. This also challenges the conventional belief, whereby shear layer structures are seen to represent stable combustion.

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Abstract

Synergistic Effects in Steam Gasification of Biomass and Plastic Waste Mixtures

Energy recovery from wastes, also called the Waste-to-Energy (WTE), is of pinnacle importance for renewable and sustainable energy development. Steam co-gasification of biomass and waste plastic mixtures was examined in a semi-batch reactor at 900 oC and atmospheric pressure, using different types of plastics with data reported on BPC (black polycarbonate), PET (polyethylene-terephthalate), and PP (polypropylene), at different biomass to plastic mass ratios. The syngas composition was measured using a micro-GC. The synergy was quantified from direct comparison of cumulative gas yields with the corresponding weighted aggregate results from the gasification of separate feedstock components. Synergetic effects were observed in the product gas yields. While the total syngas, H2, CO, CO2 yields were enhanced using mixtures, the heavier hydrocarbon gas yields reduced with net reduction in higher hydrocarbon yield (PP> BPC > PET). The increments in H2, CO with the reduction in hydrocarbon yield revealed the synergetic enhancements in the secondary steam reforming reactions. The carbon conversion and energy efficiency results revealed no inhibitive effects for any of the plastics reported here; it showed an increase in the case of BPC. The absence of loss in efficiency with increase in product gas grade motivates for further studies into both fundamental reaction mechanism studies along with demonstrative gasifier studies to understand the kinetics and feasibility issues respectively. The investigations into such mixtures provides a pivotal role to support biomass gasification plants with waste plastic feed-stocks.

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Peter Lindstedt studied at Chalmers Tekniska Högskola, Göteborg, Sweden, where he received a MEng in Chemical Engineering in 1980. At Imperial College, he received a PhD from the Department of Chemical Engineering. Peter then moved to Mechanical Engineering, where he was awarded the title Professor of Thermofluids in 1999, served as head of the Thermofluids Division from 2000 to 2010 and as Director of Research from 2003 to 2013. In 2013, he was elected Consul for the Faculty of Engineering and Business School for the period 2013 to 2016. Peter has published over 100 peer reviewed archival journal and conference contributions and has received the Gaydon Prize and the Sugden Awards. Invited lectures include a plenary on the Chemical Complexities of Flames at the 27th International Symposium on Combustion. He is a Director on the International Board of the Combustion Institute (2006 to 2018) and served as associate editor for Combustion and Flame from 2000 to 2010. He is an editorial board member of Combustion Theory and Modelling and Progress in Energy and Combustion Science. Peter served as the Technical Program Co-Chair (with Ron Hanson, Stanford University) for the 30th International Symposium on Combustion that celebrated the 50th Anniversary of the Combustion Institute. Peter also serves on the program committee for the International Workshop on Measurement and Computation of Turbulent Flames (TNF) and the scientific advisory committee for the International Sooting Flame (ISF) workshop.

Abstract

External enthalpy-controlled fuel lean and rich premixed combustion

The use of external enthalpy support (e.g. heat recirculation) facilitates combustion processes with significantly reduced emissions and fuel consumption. For example, low NOx levels can be achieved by reducing the flame temperature through stable thermally supported ultra-lean combustion. Under fuel rich conditions, the thermochemical state of an external enthalpy source can alter particulate formation and oxidation reactions. The present work illustrates both aspects. The impact of the thermochemical state of the external enthalpy support on (i) the burning mode of fuel lean (=0.5) turbulent DME/air flames at constant Damköhler (Da = 0.2) and turbulent Reynolds number (Ret =350) and (ii) the sooting tendency of fuel rich (1.8 to 2.4) ethylene/air flames at 60 < Ret < 100. The premixed flames were aerodynamically stabilised against thermally equilibrated hot combustion products (HCP) in a back-to-burnt opposed jet configuration featuring fractal grid generated multi-scale turbulence. The HCP temperature was varied from 1200 < T_{HCP} < 1600 K and 1500 < T_{HCP} < 1700 for lean and rich combustion, respectively. The lean flames were characterized using simultaneous Mie scattering, CH_2O and OH-PLIF and PIV measurements and subjected to a multi-fluid analysis (i.e. reactants and combustion products, as well as heat release, low and high temperature reactive fluid). The PIV setup was exchanged by elastic light scattering diagnostics in order to identify the soot inception point, while presence of polycyclic aromatic hydrocarbons (PAHs) as detected using a PLIF setup. The study quantifies the burning mode changes of the fuel lean DME flames by means of (i) fluid state and (ii) conditional velocity statistics. The impact of the external enthalpy support on particulate formation is delineated by means of (iii) soot intermittency and (iv) soot inception as a function of bulk strain.

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Abstract

Early Detection and Control of Lean Blowout in Gas Turbine Combustors

Lean blowout (LBO) is a serious problem in combustors of both land-based gas turbines and aero engines. In power station gas turbines, lean blowout causes lengthy shutdown leading to loss of power generation while in aero engines, it can lead to fatal accidents. Since lean blowout limits are affected by the operating conditions, it is not possible to define the LBO limit a priori. Consequently, it is necessary to develop techniques for online detection and control of LBO. Power station gas turbines mostly adopt lean premixed mode of combustion to minimize NOx emission. But in aero-engine gas turbines, the combustion takes place in partially premixed mode. In this presentation, some recent work on development of LBO detection strategies based on optical sensor data that are robust enough to be equally applicable for both premixed and partially premixed flames will be discussed. In addition, some ongoing work on control of LBO will also be presented.

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Dr. Amitava Datta is a Professor in the Department of Power Engineering of Jadavpur University. He completed his graduate education in Mechanical Engineering from Jadavpur University and his PhD from IIT Kharagpur. Dr. Datta is a recipient of Alexander von Humboldt Fellowship in Germany in the year 2000 and worked at Lehrstuehl fuer Technische Thermodynamik in the University of Erlangen Nuernberg. His research interests include combustion, atomization, energy, thermodynamic modeling and application of CFD in reacting flows, microfluidics and biological flows. Dr. Datta has completed guidance of 14 PhD thesis and several Master's thesis. He has authored nearly 175 research papers in various peer reviewed International Journals and in National and International conferences. He has also authored a text book on Combustion and several book chapters.

Dr. Datta has undertaken several sponsored research projects as principal investigator and co-investigator. He is actively involved in various administrative responsibilities in his University. Presently Dr. Datta is serving his second term as Head of Power Engineering Department. He is also the Director of the University Internal Quality Assurance Cell. He has served in various national committees in his professional capacity. He was in the executive board of the Combustion Institute, Indian Section and is presently in the Joint Working Group on Combustion set up by GTRE, DRDO. He has also served as an expert for Russian Science Federation.

Abstract

Combustion Characteristics of Biomass-based Fuels for Engine Applications

Internal combustion engines are widely used in different applications of transportation, industrial, agricultural and power generating sectors. Petroleum based liquid fuels of different varieties are commonly used as fuel in these engines. However, the use of these fuels is constrained by the adverse effects on the environment and limited reserve of the resources. Biomass based fuels, if used in engines either totally or partially, can overcome the limitations of conventional fuels. However, for using the bio-derived fuels in engines, it is required to study their combustion characteristics relevant for the engine operation.

The use of syngas blended with conventional fuels in spark ignition engine can reduce the dependence on petroleum based fuels. Two important combustion characteristics in spark ignition engines are flame speed and ignition delay. Following the ignition and the preparation phase, flame propagation occurs in the fuel-air mixture inside the combustion chamber of a spark ignition engine. Though the flame propagates as a turbulent premixed flame its propagation velocity can be directly linked with the laminar burning velocity of the fuel air mixture. As the flame propagates through the engine combustion chamber, the flame front divides the gas mixture into two parts- burned and unburned. The temperature of the unburned gas increases due to heat transfer from the burned side. The autoignition of the end gas leading to abnormal combustion largely depends on the ignition delay of the gas mixture. It has been found that the blending of syngas augments the laminar burning velocity of isooctane due to increase of the thermal diffusivity of the reactant mixture and alteration in the chemistry of the flame reactions. For the mixture of 30% isooctane/70% syngas, the laminar burning velocity and the ignition delay time values are very close to those corresponding to pure isooctane. Exhaust gas recirculation is employed in S.I. engines to increase the part load efficiency and also for knock-minimization. It is seen that the reduction in laminar burning velocity due to the dilution by the recirculated exhaust gas can be compensated by an increase in the unburnt gas temperature. The effect of the exhaust gas dilution on the ignition delay time of 30% isooctane/70% syngas-air mixture has been found to be negligible.

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Abstract

Computational-Analytical Methods in the Hybrid Solution of Energy Problems

This lecture reviews both hybrid numerical-analytical integral transforms and hybrid lumped-differential formulations for handling diffusion and convection-diffusion problems. Particular emphasis is given to recent developments that extend the applicability and the computational performance of these hybrid methodologies, towards more accurate, robust and less time-consuming simulations in comparison to purely numerical approaches, as applied to the ample fields of fluid flow and heat and mass transfer. The aim is to provide alternative solution paths that can be particularly relevant in computationally intensive tasks, such as in inverse problem analysis, optimization studies, and simulations under uncertainty, when the direct problem solution is usually required to be obtained for a large number of parametric variations. In this presentation, a few relevant problems in nuclear energy applications have been selected for illustration of the methodologies capabilities, including the analysis of uranium enrichment by gas ultracentrifuges, the thermal analysis of high burnup nuclear fuel rods, the simulation of radioisotopes migration from waste trenches and soils in uranium mining and milling, and in the thermal analysis of wet storage for spent nuclear fuel elements.

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Abstract

JAXA's Activity on Alternative Jet Fuels and Combustion Experiments Using Combustors for Aeroengines

Japan Aerospace Exploration Agency (JAXA) is conducting research on production and use of alternative fuels for gas turbines including aeropropulsion in cooperation with industries, institutes and academia in Japan. In the presentation, the current activities on alternative fuels and some experimental results of combustion rig test using several types of low-emission combustors for aeroengines with fuels already certified for aviation (HEFA) and fuels made from wasted plastics (HiCOP). The experimental observations revealed suppression of non-volatile particulate matter using HEFA fuel compared to that observed from normal kerosene. Moreover the combustion instability appeared on concentric lean burn burner was suppressed with the use of HEFA. HiCOP fuel is a recycle fuel made from wasted plastic thorough fluid catalytic cracking and fractionation, called HiCOP technology. Chemical analysis and combustion test of HiCOP fuel were performed to evaluate the possibility of using HiCOP fuel as an alternative fuel for gas turbines. A single can RQL (rich burn quick quench lean burn) combustor was used to examine combustion behavior of HiCOP fuel and petroleum kerosene with the goal to investigate the effect of fuel property on combustion performance and exhaust emissions. The results showed that the combustion performance of HiCOP fuel to be quite similar to kerosene, producing less particulate matter in the exhaust gas, while other harmful emission such as NOx, HC and CO were similar to each other. HiCOP fuel turned out to have a large potential to be an alternative fuel for gas turbines. Currently more research is being performed to satisfy all the physical and chemical specifications.

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Pr. Dr. Ing. R. Bennacer is an Engineer in Mechanical field (1989), and he got his PhD thesis at Pierre et Marie Curie University (Paris 6) in 1993. He worked as lecturer in the University Paris XI (1993/94), became an associate professor at Cergy Pontoise University in 1994 and full Professor in 2008. He moved as senior Professor to the prestigious school Ecole Normale Superieure (Paris-Saclay) since 2010. He becomes an Exceptional National Class Professor since 2017. He is also adjunct professor at Tianjin Uni. of Comm. (China) and UMBB Univ. He assumed several responsibilities, director of the LEEVAM research team (2003-2007), Licence degrees (2008-2010), Aggregation title (2010-2011), Master research degree (2011 2013), Transfer and Environmental Research Unit (CNRS LMT-Lab) (since July 2012) and dean of Civil/Environmental department (Oct. 2012/Sep. 2016). His present research activity is within the LMT laboratory where he manages Transfer and Environmental Research Unit. His Research field covers wide spectrum and several domains. It covers the building material for energy applications or on durability aspect, renewable and energy system. The expertise covers the direct numerical simulation including CFD coupling on multi-scales. The previous approach is consolidated by analytical or reduction approach in order to identify the instabilities and global behavior bifurcation and similarity controlling parameters in multiphysics situations. He published around 10 book chapters and more than 150 referenced international journals.

Abstract

Smart and Adaptive Structured Heat Exchangers: Functionality and Substantiality

The energy systems, used to produce or to convert contribute significantly to people life quality and must be efficient and weak energy consumption to produce and while in service. The aim of this work is to present the behavior flow and transfers through a multi-structured heat exchanger and to achieve the optimal thermal, species (IAQ) and flow properties of the skeletal phase. Either the adopted optimization approach will fit with the equivalent perfect insulator (weak flow) or with the maximum heat exchange (weak pressure drop). Therefore, in a specially made approach, we generate analytical controlled complexity structure. The direct numerical simulation (finite volume method) was applied to study a multiphysics problem through such inhomogeneous porous media foam-type. The optimization cost function coupled with the two previous programs optimize and propose the optimal structure. The local flow-heat mass and deformability ability and the structure morphing are the main keys for enlarging the nominal working conditions (adaptive structure).

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Abstract

How a spray interacts with swirling flow

In this work, the near field breakup and atomization of liquid sheet in a co-annular swirling gas flow field is presented. High-speed speed shadowgraphy is employed to characterize the global features and breakup dynamics of liquid sheet across a wide range of airflow rates. The parameter momentum ratio (MR) is used to illustrate the results. Breakup regimes are constructed based on the instantaneous visualization of the liquid sheet. In this study, the transition from weak to strong, spray-swirl interaction is explained based on momentum ratio (MR). Proper Orthogonal Decomposition (POD) is implemented on instantaneous PIV (and shadowgraphy images, to extract the energetic spatial eigen modes and characteristic modal frequencies. POD results suggest the dominance of KH (Kelvin-Helmholtz) instability mechanism (pure axial shear, axial + azimuthal shear) in swirl-spray interaction. For instance, the large scale coherent structures of swirl flow exhibits different sheet breakup phenomena in spatial domain. For instance, flapping breakup is induced by central toroidal recalculation zone (CTRZ) in the swirling flow field.

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Ryo Amano is a professor of Mechanical Engineering at the University of Wisconsin-Milwaukee and has been engaged in the research on energy and aerospace subjects. The specific research areas that he has worked include turbulence theory, aerospace study, renewable energy on the wind, hydro, and biomass, gas turbine cooling technology, multiphase flow, combustion, water, and turbomachinery. He is currently an associate editor for ASME Trans. Journal of Energy Resources Technology and the editorial member for International Journal for Rotating Machinery, International Journal of Computational Methods and Experimental Measurements, IIRE Journal of Renewable Energy, and several others. He has published four books, 33 book chapters, over 130 journal papers, and over 400 conference proceedings. He is a recipient of ASME George Westinghouse Gold Medal, AIAA Energy Systems Award, and AIAA Sustained Service Award. He is currently ASME Life Fellow and AIAA Life Associate Fellow.

Abstract

Investigation of Two-Phase Flow and Liquid Breakup Behavior in Gas Flow Field

This paper presents a fundamental study of liquid-phase aluminum oxide propulsion process in high-speed gas flows. The straight two-phase flow channel experiment setting enables us to investigate the liquid breakup process in macro scale. The team has achieved in developing a quantification method that includes analyzing high-speed camera image process, which extracts data in images and provides information. Some of the data are liquid droplet count, size of the distribution, wave frequency, and time averaging two-phase free boundary. We have discovered that liquid breakup mechanism is proportional to gas-droplet velocity difference square, gas density, and liquid droplet size. The properties are inversely equivalent to liquid surface tension.

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Prof. de Lemos obtained his Bachelor and MSc degrees in Mechanical Engineering from the Pontifical Catholic University of Rio de Janeiro (PUC-RJ) in 1977 and 1979, respectively. In early 1983, he obtained his PhD degree from Purdue University, USA. He spent a year as Assistant Professor at PUC-RJ in 1984, followed by two years as Resident Associate at Argonne National Laboratory, Illinois. In 1986, he joined the Aeronautical Institute of Technology - ITA in São José dos Campos, Brazil. He is Full Professor at ITA, founder and head of the Computational Transport Phenomena Laboratory - LCFT and the newly established Competence Center for Energy - CCE. He also serves as Head of the Department of Energy. From 1991 to 1992, he was Visiting Scholar at Ruhr-Universität-Bochum, Germany. In early 1992, he became Member of the American Society of Mechanical Engineers - ASME and in 2009 he was promoted to the "Fellow" grade by ASME. He and has advised 11 PhD and 22 MSc students. Prof. de Lemos has set a new mathematical framework for novel treatment of turbulent flow, heat, and mass transfer through permeable media. On the overall, he has published more than 360 articles in conference proceedings and journals in addition to nine book chapters and five books. He is member of the Honorary Editorial Advisory Boards of Int. J. Heat & Mass Transfer and Int. Comm. Heat & Mass Transfer, member of the Editorial Advisory Board of J. Porous Media and Editorial Board Member of Int. J. Dynamics of Fluids and Int. J. Applied Engineering Research. He has coordinated several joint research projects with DLR and Uni-Erlangen, Germany, and has delivered seminar lectures in Brazil, USA, Portugal, Tunis, Lebanon, Italy, France, Germany, South Korea, Romania, UAE and Japan. He is Consultant to Brazilian Education Ministry (CAPES), Brazilian National Research Council (CNPq) and São Paulo State Research Foundation (FAPESP). Prof. de Lemos´ research interests involve computational thermo-fluid dynamics, transport phenomena, porous media, thermal engineering, aerodynamics, gas turbines, advanced fossil and renewable energy systems (wind, solar, biomass), high performance computing, turbulent reactive flow, computational mathematics, combustion dynamics, modeling and simulation of thermochemical systems, fuel cells, gasification processes and CO2 capture and storage technologies.

Abstract

Turbulent Flow, Heat and Mass Transfer in Permeable Media

Engineering equipment design and environmental impact analyses can benefit from appropriate modeling of turbulent flow in permeable media. A number of natural and engineering systems can be characterized by some sort of porous structure through which a working fluid permeates. Turbulence models proposed for such heterogeneous media depend on the order of application of time and volume average operators. Two developed methodologies, following the two orders of integration, lead to different governing equations for the statistical quantities. This lecture reviews recently published methodologies to mathematically characterize turbulent transport in porous media. The concept of double-decomposition is discussed and models are classified in terms of the order of application of time and volume averaging operators, among other peculiarities. Thermal non-equilibrium between phases is discussed. For hybrid media, involving both a porous structure and a clear flow region, difficulties arise due to the proper mathematical treatment given at the interface. This lecture discusses numerical solutions for such hybrid medium. In addition, macroscopic forms of buoyancy terms are presented for both mean and turbulent fields. Cases reviewed include heat transfer in porous enclosures, cavities partially filled with porous material, moving bed systems, combustion in porous media and double- diffusion effects in porous media.

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Pr. M. El Ganaoui is a full professor at the University of Lorraine and researcher in the Jacques Villermaux Federation for mechanics, energy and processes (FR 28 63/LERMAB). He is heading the research group in the Henri Poincaré Institute of Technology in Longwy. Previously, he was an Asst. Professor in the University of Limoges and the SPCTS laboratory where he was responsible for the Physics Department (2004-2010) and the international cooperation service (2006-2010) in the Faculty of science and technology. His research aims to understand heat and mass transfers through modeling and numerical simulation with a specific activity in the field of the solid -liquid-vapor phase change. Applications concern materials and energy and benefit to energy systems including sustainable building (Eco-materials). He teaches the mechanics of continuous media, heat transfers, and numerical methods. He was advisor of more than 25 PhD Thesis with strong international interaction noticeably in the Euro-Mediterranean context. He participated/managed the PAI Australia, Canada, Maghreb, China. He participated in the Edition of more than 10 special issues and conference proceedings, co-authored over than 150 publications in journals (rank A) and participated in more than 100 Int. Conf.; he co-organized ten. He is member of many international scientific societies in mechanics and heat transfers.

Abstract

Heat and Mass Transfer on the bulk of Doctor Engineer Debate

Dialogue between doctor and engineer will remain crucial for societal progress. It is universal to all cultures and systems of knowledge. Modeling of heat and mass transfers have helped on more than a century the understand phenomena, model, control and make valuable return on the society. This dialogue will be illustrated through research results in the field of sustainable energy and building. Improving energy efficiency and thermal comfort in the buildings, by using functional wood, and/or phase change materials (PCM) from the laboratory scale to the city scale was achieved. The main goal is always to keep the communication between laboratories and companies so it is central via such doctor and engineer exchange. Such dialogue answer on both immediate question and challenges and the long term and society mutation. The technological platforms are also used in teaching in order to produce and integrate such knowledge in the engineer background allowing the technological veil. We demonstrate how simple approach and sustainable materials (bio-resources) can answer and complete the other complex multi-sensors and technological strategies developed on smart house and cities.

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- Born in 1967 in Italy, Master Degree in Mechanical Engineering in 1992, University of Naples Federico II, Ph.D. in 1995, University of Naples Federico II. Thesis on numerical and experimental natural convection in channels;
- 1994, Visiting Ph.D. student at Idaho State University, USA; Numerical analysis of the electronic components cooling and analytical solutions of heat transfer in solid;
- 1998-2002 junior researcher and 2002-today Associate Professor of Applied Thermodynamics and Energy Management at University of Campania;
- Member of the College of Doctorate in "Mathematics, Physics and Engineering applications" teaching courses on Numerical Methods in Physics and Engineering;
- Leading researcher of scientific projects aimed to produce bio-hydrogen and bio-methane from animal manure and organic fraction of municipal solid waste;
- Leading researcher of a scientific project on Ground Energy Pile Heat Pumps;
- Invited speaker at several conferences on the use of bio-hydrogen in IC Engines;
- Co-author of 50 scientific publications on international journals, many others presented at international and national conferences and several book chapters;
- Main research interests are: numerical heat transfer, biomass energy conversion, alternative fuels for internal combustion engines, ground coupled heat pumps.

Abstract

Residual Biomass Resources: An Invaluable Reservoir of Energy and Matter

Earth can be an unlimited and invaluable source of both Energy and Matter. In fact, just to consider residual biomasses, such as livestock farming, agro-industrial food industry wastes and organic fraction of municipal solid waste (OFMSW), there are plenty of organic compounds. Simple and complex carbohydrates, among which cellulose, but also proteins, lipids and other metabolites can be converted to gaseous products, such as hydrogen, methane and carbon dioxide to different extent, and also to chemical building block molecules, such as lactic acid. We investigated anaerobic fermentation of water buffalo manure for hydrogen and methane production also assessing the type of the microbial endogenous populations focusing on the biogas production. Results are presented showing that water buffalo manure can be conveniently used to produce biogases by anaerobic digestion process without any addition of nutrients or external microbes. In addition, interesting data about the carbon/nitrogen ratio of the substrate and the effects of manure pre-treatments on the biogas production are provided. Then, results of bio-methane and bio-hydrogen blends as fuel for internal combustion engines are discussed, focusing on the mechanical, range, pollutant emissions, and performance. Discussion on alternative and valuable process chains that can be set up to produce lactic acid by means of anaerobic fermentation using food and agro-industrial processing waste and its possible uses is carried out. The use of lactic acid as additive in internal combustion engines emissions will be evaluated to reduce pollution emissions.

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Dr Manish K Tiwari is a Lecturer in the Mechanical Engineering Department of the University College London. He received his PhD from the University of Illinois at Chicago (UIC). After graduating, he first did his postdoctoral research in the Laboratory of Thermodynamics in Emerging Technologies at ETH Zurich. After two years as a postdoc, he became a Group Leader in the same Laboratory and stayed on at ETH Zurich for two more years. Dr Tiwari's research focuses on physics of small scale transport phenomena with an emphasis on developing energy efficient technologies. He has published papers in high quality journals such as Nature Communications, PNAS, Nano Letters, Nature Materials etc. Some of these papers were also selected for unsolicited highlights in journals such as Nature and Nature Physics. He is an European Research Council (ERC) Starting Grant Awardee and a member of EPSRC Early Career Forum in Manufacturing Research. He was part of the ETH Zurich representation to the prestigious Global Young Scientist Summit (GYSS) in Singapore in 2013. He also received the Dean's Scholar award during his doctoral research at UIC, which is the most prestigious of the UIC doctoral fellowships, and a gold medal for his masters studies at Jadavpur University in India.

Abstract

Small Scale Transport Phenomena For Energy-Water-Food-Environment Nexus

Addressing energy, water, food and environment related challenges are vital to survival of our species and requires a holistic, multidisciplinary approach. These challenges are often interconnected; for example, using ethanol from corn as fuel, for better environmental benefits, can drive up the price of corn for food. This broad concept is referred as energy-water-food-environment nexus. In the current presentation, I will seek to make the case for how fundamental investigation of small (micro/nano) scale transport phenomena can play an important role in addressing this global grand challenge. I will start by introducing some key features of a number of small scale thermofluidic technologies, which can help recover 'low-grade' heat from data centres and solar cells, improve their overall energy efficiency and can also facilitate secondary usage such as sea water desalination for drinking water production, absorption refrigeration systems for food and pharmaceutical preservation, etc. In particular, I will share results obtained using a number of microscale heat transfer platforms and diagnostic techniques for efficient thermal management, heat recovery and enhanced mixing. On a related subject, I will also introduce a class of nanoengineered coatings that can minimise the use of water in cleaning solar panels, thereby facilitating sustainable solar energy production in arid climates where solar energy is typically abundant but drinking water is scarce. Finally, I will finish by sharing some perspective on a number of research opportunities in this exciting area.

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Kemal (Kemo) Hanjali , PhD (Imperial College), served as Head of Thermal and Fluids Sciences at TU Delft (1994-2005), and prior to that as Professor at the Michigan University of Technology, USA, and the University of Sarajevo, BH. He was a guest Professor at the Univ. of Erlangen and TU Darmstadt, held a Marie Curie Chair at "Sapienza" University of Rome (2007-10) and was Lead Scientist at the Novosibirsk State University, Russia (2011-16). He has published on topics of fluid flow, heat transfer, combustion, MHD, and has been widely recognized as a major contributor to the development of turbulence models. He also worked on the developments of piston and screw compressors, entrained coal-gasification, pulse combustors, detonation wave technique for deposit removal. He (co)-authored 4 books, edited 12 volumes and served as Editor-in-Chief of the "Flow, Turbulence and Combustion" journal (Springer, 2005-15). He received a Max Plank Research Award (Ge), a D.Sc.(Eng) from the Univ. London (UK), Dr.h.c. of the University of Reims (Fr), and is an Int. Fellow of the Royal Academy of Engineering (UK), a Fellow of ASME, IoP and ICHMT. He is 'Commander 1st Class of the Order Lion of Finland' and 'Officer of the (Royal Dutch) Order Oranje-Nassau'

Abstract

Will RANS Survive LES: A Perspective in Energy and Environmental Engineering

Despite the growing popularity of large eddy simulation (LES), Reynolds-averaged Navier-Stokes (RANS) turbulence closures remain the bedrock of industrial computational fluid dynamics (CFD). Further increase in the computing power is more likely to advance innovations in RANS concept and its blending with LES rather than yield to true LES. Both the RANS and hybrid LES/RANS schemes can benefit from advanced RANS models as proved by scrutiny in complex, industrially relevant, separating, swirling and buoyancy-driven flows. A triple-decomposition analysis of pseudo-deterministic eddy structures in crossflow over a cylinder (a paradigm of RANS failure) reveals the importance of accounting for the stress anisotropy and stress-strain eigenvectors phase lag in capturing the essentials, including the low-frequency modulation of vortex shedding. In hybrid schemes, although the role of RANS is reduced to relatively small regions, for internal flows in complex passages and involving various surface phenomena the choice of RANS maters for accounting for versatile effects of bounding walls and the proper receptivity to the LES forcing at the interface. This is illustrated by examples of generic- as well as real industrial flows relevant to reliability, availability and efficiency of some new and conventional energy conversion technologies: off-design operation of hydro-turbines involving vortex ropes and cavitation, internal blade cooling and tip-leakage in thermal turbomachinery, combustion of mechanically-activated pulverized coal, environmental flows over complex terrains at severe conditions, and others.

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Dr. Debasis Chakraborty did his PhD in Aerospace Engineering from Indian Institute of Science (IISc), Bangalore. He has started his career as Scientist/ engineer in VSSC and worked for 15 years, In Nov'2001, he joined DRDL and currently he is the technology director of Directorate of Computational Dynamics (DOCD). Both in VSSC and DRDL, he has worked extensively in numerical simulations of high speed reacting and nonreacting flows and provided useful aerodynamics and propulsion design inputs for satellite launch vehicles, strategic and tactical missiles. He is the fellow of Indian National Academy of Engineering, Institute of Engineers and Aeronautical Society of India and has received many awards including DRDO Scientist of the year, DRDO award for best innovation/ futuristic development etc. He was the INAE-AICTE Distinguished Visiting Professor at IISC, Banglaore and visiting professor at University of Hyderabad. He has published more than 220 research papers in various international journals and conferences in the area of CFD. He was the member of aerodynamics and propulsion panels of AR&DB and expert panel member of National Supercomputing Mission and National Center for Combustion Research and Development (NCCRD). He was the guest editor of special issue of Defence Science Journal on CFD.

Abstract

Application of CFD Methods in Aerospace Propulsion Design

Currently, CFD has matured into a rich and diverse subject for both basic fluid dynamic research and a reliable and robust design tool for aerospace propulsion. Simultaneous developments of new computers, numerical algorithms, physical and chemical models of flow physics have made CFD an integral part of the propulsion design process. While experimental testing will always remain important for the design, CFD reduced the dependence on the more expensive, time consuming experimental testing or rather using experimental work more effectively and economically.

A host of indigenous RANS, LES and DNS solvers are developed in DRDL using state of art numerical techniques for prediction of complex internal flow inside the propulsion systems. Important User Defined Functions (UDFs) are developed to apply commercial CFD solvers in design. Open source CFD software has been customized to solve many complex propulsion problems. Systematic validations were carried out through comparisons against reliable experimental results before applying these indigenous, opensource and commercial CFD tools in the design exercises.

CFD methods facilitated design of propulsion systems of various ongoing and future missile projects of DRDL. Extensive nonreacting and reacting simulations were carried out for the development of flightworthy scramjet propulsion system for hypersonic airbreathing cruise vehicle and CFD simulations guided the experimental testing. Excellent match is obtained between experiment and pre-test prediction for various performance and flow parameters. Accurate estimation of heat flux obtained from high fidelity CFD simulations are used in thermostructural design of the combustor. Aerodynamic and propulsion parameters obtained from end-to-end simulation (comprising of nonreacting flow in external surfaces and reacting flow in the combustor) provide vital input for mission design. CFD based jet vane correlations are adopted in the flight computer for tactical missiles and forms an integral part of missile control and guidance. The problem of high temperature in the base cavity caused due to interaction of free stream and exhaust plume at high altitudes could be analysed only through CFD methods. Performance prediction of installed air intake of ramjet missiles, Solid Rocket Motor (SRM) port flow field analysis, combustion instability prediction of SRM, Plume-canister / plume-launcher interaction etc. are some of the other notable applications of CFD methods in propulsion system design. Understanding of complex flow phenomena inside the propulsion system has reduced the developmental cost and time of the system significantly. Development, validation and application of CFD codes for practical propulsion systems will be highlighted in the presentation.

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Yunho Hwang is a research professor at the University of Maryland and serves as an associate director for the Center for Environmental Energy Engineering. His research focuses on energy conversion systems and energy efficiency by developing innovative processes and improving existing processes. During his 34 years careers, he published 256 journal and conference papers, ten patents, and co-authored ten books and book chapters. He is ASME fellow and recipient of ASHRAE's distinguished service award and exceptional service award. He served as a lead faculty in 2017 Solar Decathlon hosted by the U.S. DOE and won Second Place; and participated in MaxTech and Beyond, Ultra-low Energy Use Appliance Design competition hosted by the U.S. DOE and won First Place twice in a row in 2012 and 2013. He organized 2014 International Sorption Conference and 2015 ASME Energy and Sustainability Conference as a general chair. He serves as an Editor for Energy (Elsevier, Netherlands) and Int. Journal of AC&R (World Scientific, US).

Abstract

Development of Advanced Cooling Technologies for Sustainable Future

Buildings share approximately 40% of annual worldwide energy consumption. While air-conditioning, heating and refrigeration are responsible for approximately 40% of building energy usage, their share is projected to grow dramatically due to expanded adoption of air-conditioning and refrigeration for better thermal comfort and food safety, respectively, especially in developing countries under hot climate zone. To mitigate direct and indirect CO2-equivalent emissions from those systems, which are about 7.8% of global emissions, the development of advanced cooling technologies with more environmentally-friendly low-GWP alternative refrigerants is urgently needed. This paper provides update on the latest research efforts for the development of more efficient advanced cooling technologies towards near-Zero Energy Buildings (nZEB). First, advances in both conventional and non-traditional cooling technologies are explained. Second, the integration of advanced cooling systems with nZEB are explained through the case study, which also demonstrates how the academia can integrate an energy research to the educational program.

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Prof. Kunio Yoshikawa was born in 1953 in Tokyo, Japan. He is a Professor at Tokyo Institute of Technology and an Associate Editor of Applied Energy. His bachelor, master and doctor degrees were awarded from Tokyo Institute of Technology. His major fields are energy conversion, waste management and environmental engineering. He has been working in Tokyo Institute of Technology for more than 38 years as a research associate, an associate professor and a professor. He has published nearly 200 journal papers with the major award of AIAA Best Paper Award, ASME James Harry Potter Gold Medal, JSME Environmental Technology Achievement Award and Best Educator Award of Tokyo Institute of Technology.

Abstract

High Quality Solid Fuel Production from Biomass and Wastes Employing the Hydrothermal Treatment

Up to now, the only commercialized ways of municipal solid waste (MSW) treatment are mass land-filling and mass burning. In Japan, most of burnable wastes are incinerated, but not in other countries, and still land-filling is the most popular way of waste treatment all over the world. But the world recent trend is to prohibit or limit land-filling of wastes while citizens do not want to increase waste incineration in developed countries as well as developing countries. On the other hand, major part of the world is discharging non-segregated municipal solid wastes. Thus we have to find out the utilization ways alternative to incineration for non-segregated MSW. Pre-treatment of wastes requires crushing, drying and deodorizing, which are normally different processes. But we have developed innovative hydrothermal treatment technology (HTT) which can perform these three pre-treatment functions in one process utilizing high pressure saturated steam. Figure 1 shows the operating principle of HTT. Non-segregated MSW are fed into the reactor, and then, 220?, 2.5MPa saturated steam is supplied into the reactor for about 30 minutes and the blades installed inside the reactor rotates to mix MSW and steam for about 10 minutes. Then the product is discharged after extracting steam. The product is powder-like substance and the moisture content is almost the same as the raw material, but is easily dried by natural drying. The inert material such as metal, glass and stones can be easily sieved out after drying. There is almost no bad smell in the solid products, and the products can be used as solid fuels which can be easily mixed with coal for power generation or cement production. Only 10-15% of the product is enough for steam production in a boiler. HTT has already commercialized in Japan, China and Indonesia.

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Gabriel D. Roy received his B.S and M.S degrees in Mechanical Engineering and his Ph.D in Engineering Science. He served as a faculty member in India and U.S. and served as thesis advisor for over a dozen graduate students. During his industry career at TRW (currently Northrop Grumman Corp), he received the TRW Roll of Honor Award, and two patents on combustor and atomizer. During his position as Program Manager for Energy Conversion and Advanced propulsion, he introduced new areas of research including, but not limited to strained high-energy hydrocarbon fuels, MHD underwater propulsion, pulsed and continuous detonation engines, combustion control, jet noise reduction, biofuels etc. He managed the pulsed power program for the Ballistic Missile Defense Organization where he introduced novel switches for power management. He also served as the Navy Program Manager for the Versatile Affordable Advanced Turbine Engines (VAATE) and the Advanced Versatile Engine Technology (ADVENT) programs, and the Navy's SBIR, STTR and DURIP programs. Dr. Roy served as Associate Director at the Office of Naval Research Global, Singapore, where he sponsored international research programs and conferences worldwide, and served in advisory boards and presented keynote lectures. He does independent consultation now. He received the Secretary of the Navy Meritorious Civilian Service Medal, AIAA Energy Systems Award, ASME Jean F Louis Energy Systems Award, JANNAF Combustion Award, ASEI Exceptional Merit Award, IWCEM Outstanding Contribution to Science and Technology Award. He has over 20 books and 120 publications and research papers to his credit. He is Fellow of AIAA and served as Associate Editor of the AIAA Journal of Propulsion and Power. Dr. Roy is a writer and an artist and won National Awards in Painting.

Abstract

Conventional Propulsion Fuels to Sustainable Biofuels - The Road Ahead

With increasing number of automobiles and airplanes, the demand of propulsion fuel also increases. Not only the natural petroleum resources are getting depleted, the costs of the final product - propulsion diesel, gasoline or aviation fuels are fluctuating with an increasing trend. International political scenario only adds to the difficulties in supply. While sustainable biofuel is a promising alternative, it is a tough competition with a gallon of gasoline with the desirable thermodynamic characteristics, ease of storage, shelf life and transport. The existing mines are not taking away any aural land. The well-established petroleum industry, though invests and participates in biofuel will be counting more on the profits from their existing plants. So it is very important that not only incentives are of order from governments, but also regulations should be in place mandating progress and deadlines in biofuel production and usage so that this technology can bring fruition in a timely manner. Natural food products and aural land should not be utilized for fuel production. The past decade has seen substantial progress in this direction. New processes and source preparation have emerged. This talk will provide an overall perspective of recent progress made worldwide in biofuels, government regulations and mandates, factors decelerating progress, utilization of land and seashore more effectively and address related issues.

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Presently working as Professor of Mechanical Engineering at Delhi Technological Universiy (Formerly Delhi College of Engineering), Prof. Naveen Kumar did B.E. from Dayal Bagh Educational Institute, Agra, M.Tech. from IIT Delhi, and Ph.D. from the University of Delhi. He is a Fellow of Institution of Mechanical Engineers (FIMechE), UK; Fellow of Institution of Engineers (FIE), India and Charted Engineer, Engineering Council, UK. His research interests include alternative fuels with special emphasis on biofuels, decentralized energy systems, renewable energy, waste recycling and sustainable development. He has made a significant contribution to R&D in the area of alternative fuels for use in a variety of off-road engines and vehicles. He has guided a large number of Ph.D. and M.Tech. Students, and has undertaken Sponsored Research Projects from Government and Industrial Houses such as Ministry of New and Renewable Energy, Petroleum Conservation Research Association and Yanmar Co. Ltd., Japan. He had been a principal consultant in a World Bank Sponsored project "Fences for Fuel" in India. He also worked in an Indo-Spanish Collaborative project to develop new and fast methods of biodiesel production. He has published more than 90 research papers in the International Journals of repute and more than 100 in Indian Journals and Conferences.

Prof. Kumar has presented his research at Universities, research organization and industries abroad particularly at the University of Minnesota, University of South Florida, University of Murcia, Kongju National University, Korea Institute of Energy Research, Yonsei University, National Research Institute for Chemical Technology, Materials & Energy Research Center, Babol Noshirvani University of Technology etc. He is Editor-in-Chief of 'Journal of Biofuels'. He is also on the editorial board of many journals and works as a reviewer for many journals published by ASME, Elsevier, Springer, Wiley etc.

Abstract

Next Generation Biofuels – Opportunities and Challenges for India

India being a developing economy is using a huge amount of energy for sustaining its growth; most of which comes from fossil fuels at present. However, India is importing around 87% of its crude oil requirement, which is a major burden on the exchequer. The most potential fuel either to supplement or substitute petroleum-derived fuels in the Indian context is biofuels. Biofuels are not only renewable but environmental friendly as well. The first generation of biofuels (ethanol, biodiesel) is derived from energy-containing molecules such as starch, sugar, animal fats and vegetable oil. These fuels, however, provide only limited biofuel yields and have an adverse impact on food security. Efforts are now needed to accelerate the generation of advanced biofuels by identifying and engineering effective non-food feedstocks, improving the performance of conversion technologies and the quality of biofuels for different sectors as well as bringing down the costs. The next generation biofuels are mainly stemmed from lignocellulose, non-food materials, algal biomass, and purpose-grown energy crops on marginal lands. Biodiesel (from non-food crops), renewable diesel and bio-butanol are some of the promising biofuels which are actively pursued by research fraternity world over.

Biofuels are sustainable and have the potential to address the issues of climate change and energy security. However, challenges such as high production cost, lack of realistic support price, enforcement of mandates, poor supply chain, and adherence to quality norms are some of the deterrents for their commercialization. New Technologies such as hydroprocessing and nano-catalysts would emerge as an attractive proposition in times to come. It can be concluded that biofuels in India is still in the embryonic stage and commercial viability will take its own time.

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I received my PhD at Lund University in Sweden and have after that had several positions at the same university. I was appointed full professor in 2011. My research interest is energy in general and particularly fluid dynamic aspects of energy. Large parts of my research have been related to combustion with alternative fuels and/or oxidizers. Most of my work has been experimental, using optical measuring techniques. The dominating industry partners have been electricity utilities and manufacturers such as Siemens Industrial Turbomachinery.

For a list of publication, please refer to open google scholar profile:

https://scholar.google.se/citations?user=HpRXDwMAAAAJ&hl=en&oi=ao

Abstract

Hydrogen as Electricity Storage

Volatile power production such as wind and solar PV has in some countries now reached high shares. As a consequence of this, there are instances in time where power production exceeds the demand and there have been periods of negative electricity prices in e.g. Germany. On the other side, in absence of sun and wind, there will be a shortage of electricity that has to be covered. Large scale electricity storage remains difficult but one possible route for storage is production of hydrogen through electrolysis of water. Re-electrification can be done by firing the hydrogen in gas turbines. Present gas turbine combustors are however generally developed for natural gas (or liquid fuels) with highly different combustion properties than hydrogen. Particularly for modern premixed low emission combustors, the propensity for flashback must be coped with. Presently, most major gas turbine manufacturers are working on combustors for hydrogen or mixtures of hydrogen and natural gas.

If this kind of electricity storage proves itself in a longer time scale, other cycles may develop. Particular use can be made of the fact that electrolysis of water produces both hydrogen and oxygen and the only product of combustion with these streams is water. Although it most likely will take some time for theses cycles to reach the market, the efficiency potential is very high.

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Dr. Somrat Kerdsuwan has got a Ph.D. in Combustion from University of Poitiers, France. He has a very strong background concerning Waste Thermal Treatment Technology, Waste Management and Air Pollution Control. Currently, he is a director of the Waste Incineration Research Center, Department of Mechanical and Aerospace Engineering, King Mongkut's University of Technology North Bangkok. He has got 2009 ASME George Westinghouse Silver Medal in the field of 'Researcher, engineer and educator in the design, development and applications of wastes and low grade fuels for clean energy conversation and power production, with emphasis on alternative energy and performance characterization' as well as 2011 Best ASEAN Outstanding Engineering Achievement Award from Federation of Engineering Organization as an expert environmental and combustion engineer and his deep devotion to Waste Incinerator Research Center in recognition of an outstanding engineering project which have made significant contribution to the country's development.

Abstract

Green and Clean Energy Recovery from Old Landfill Dumpsite for Sustainable Development

With the depletion of fossil fuel due to the accelerated rate of using energy following the expansion of economic growth nowadays, in complement with the national energy security situation and the global environmental problems, it is needed to increase the usage of renewable energy. Municipal Solid Waste (MSW) is a renewable energy resource, which is considered as an environmental friendly fuel by producing less CO2 emission. All over the world, there are problems of inefficient MSW collection and improper MSW management. Nowadays, landfilling is commonly used as MSW management method because of the ease of operation with low cost. However, the increase in the population leads to the high amount of MSW and there is no available land for MSW landfilling. Additionally, uncontrolled landfilling causes many negative impacts on health and environment, as well as it can cause fire in many old landfill sites. This study focuses on the comparative study of energetic properties of MSW from dumpsite for green and clean recovery. The reclaim landfill from dumpsite with the difference ages has been compared for its energy potential properties as well as the difference in location and depth of the dumping. The upgrading of RDF from reclaim landfill to improve its fuel properties has also been discussed.

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Professor Ray Y. Lin is an Emeritus Professor at the University of Cincinnati. In 2009 he founded TaiCrystal International Technologies Co. Ltd. and is currently serving as the chairman of the company. He received a Sc.D. degree from Massachusetts Institute of Technology in Materials Engineering. From 1983 to 2010, he was a professor of materials engineering at the University of Cincinnati. He has more than 35 year experience in materials manufacturing and crystal formation. His expertise is on materials crystalline structures, crystal growth, materials manufacturing, metal composite materials, vacuum sputter deposition, infrared processing of materials and corrosion. He owns 19 US and international patents and authored more than 120 technical publications as well as three books. In addition to his professorship at the University of Cincinnati, he has also been a visiting professor at Tohoku University(1990) and National Taiwan University (1990-1991, 1994-1995), as well as a NSC Chair Professor at National Central University in Taiwan (2008-2009). He served as a science advisor for the United Nations Development Program in 1991 and on the reviewer panel of Quebec Provincial Government, Canada, Research Center Evaluation, "Fonds FCAR, Fonds pour la Formation de Chercheurs et l'Aide a la Recherche", as well as on the NASA review panel for nano science. He was Chairman of ASM Thermodynamics and Phase Equilibria Committee in 1998-2001, Chairman of TMS Process Fundamental Committee (1992-1994) and chairman of the Cincinnati Chapter of ASM International. He was inducted as a fellow of ASM International in 2001.

Abstract

PV Trend and High Efficiency PV Technologies

As SolarPower Europe reported, the world PV deployment has grown at a rate of around 30% annually over the last number of years. In India the total was 9.01GW up to 2016, about 3% of the world. Of the same period, China was 25%, 14% in Japan, 13.5% in Germany and 13% in the USA. International Business Time reported in 2015 that India planned to install 100 GW capacity of solar power by 2022, which was a five-time increase from a previous target. The solar energy condition in India is superior to most areas in the world. It is likely that PV energy in India could contribute to the power generation more effectively than others in the world. As suggested by International Energy Agency (IEA), the long-term scenario for 2050 shows worldwide solar photovoltaics (PV) capacity might reach 4,600 GW. For that, annual PV deployment of 124 GW with investment of $225 billion is required. By 2050, levelized cost of electricity (LCOE) generated by solar PV would cost between US 4¢ and 16¢ per kilowatt-hour (kWh), or by segment and on average, 5.6¢ per kWh for utility-scale power plants (range of 4¢ to 9.7¢), and 7.8¢ per kWh for solar rooftop systems (range of 4.9¢ to 15.9¢). India could play an important role in the solar energy deployment in the near future.

While the majority of PV panels deployed was of crystalline silicon types, concentrated solar thermal (CSP) and concentrated photovoltaic (CPV) show technology promises, particularly CPV. Although few major system deployments worldwide, concentrated photovoltaic (CPV) technologies remain as the most important technology that attracts many efforts for its advancement. It is well-known that the CPV cells have the best energy conversion rate(>40%) and low time dependent degradation rate, which result in lower electricity cost, less land requirement and more power generation per unit installment. Further cost reduction, increased power output, easy installation, simple maneuverability, etc. are being sought after. Among numerous programs, the most interesting one may be the DARPA-e programs called MOSAIC by more than 11 institutions including MIT, Cal Tech, U Penn, Semprius, Sharp US, Panasonic etc. This project (a total of more than $24 millions) is expected to come out with a new CPV system addressing the cell conversion rate, thin module and hybrid power generation including both photovoltaics and solar thermal power.

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Dr. Sutapat Kwankaomeng is an Assistant Professor in the Department of Mechanical Engineering at King Mongkut's Institute of Technology Ladkrabang (KMITL), Thailand. She worked in the Fluid Power Laboratory and pursued her PhD in the major of mechanical engineering and minor in engineering mechanics and aeronautic from University of Wisconsin-Madison, USA. Dr. Sutapat's areas of interest are heat transfer and thermal system design including green energy engine designs such as Stirling engine and compressed air engine, solar collector, solar power plant, biomass power plant and combined heat and power (CHP) applications. She has published over 50 international journal and conference publications. As a head of Green Energy Engine Research (GEER) Laboratory in KMITL, Dr. Sutapat with her colleagues and students designed and built many prototypes of Stirling engines and compressed air engines with various scales and applications. The free-piston Stirling engine prototype with solar power was awarded the 1st runner up in Alternative Energy Creation of iC-HiEd 2014 by Nation Research Council of Thailand. She was granted a lot of research grants and two of her projects were awarded as good projects by Office of the Higher Education Commission, Thailand. Her research prototypes have commercial potential as a small scale distributed generation.

Abstract

Feasibility Study on Integration of Beta-Type Stirling Engine-Generator and Wood Pellet Gasifier

Stirling engine is an enclosed gas engine running without internal combustion but relies on gas expansion and contraction at the hot and cold sections, respectively. This reciprocating engine is clean and environmental harmless. As a prime mover or heat pump, the Stirling cycle engine can be employed with various sources of renewable energy such as biomass, biofuel, solar energy, geothermal energy, recovery heat and waste. This research, therefore, aims to integrate a Stirling engine with a wood pellet gasifier for electric power generation. The engine is a beta-type Stirling engine with rhombic drive mechanism. Helium is used as a working gas. The prototype has swept volume of 113 cm3 with bore and stroke of 60 mm and 40 mm. The heater is a fired tube heater. Stainless steel wool is utilized as the regenerative material. The cooler is a shell and tube heat exchanger where working gas flows through many small tubes which externally circulated by water as the coolant. Dynamic balancing was evaluated both theoretical and experimental techniques. The prototype was built, tested, and developed over wide range of operating conditions such as variation of fuel consumption rate, working gas pressurization, regenerative porosity, balance weight and seal materials and methods. The prototype is coupled by 1 kW updraft gasifier. Feasibility investigation on the Stirling engine generator and gasifier system is verified numerically and experimentally to achieve both optimum power and highest efficiency of the engine system.

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Dr. Aggarwal's research and teaching interests include Combustion, Multiphase Reacting Flows, Renewable Fuels, Emissions, Clean Energy, Fire Suppression, and Microgravity Phenomena. He has authored over 350 journal and conference publications with over 5000 Google citations. His research has been funded by a number of federal agencies and companies, and has resulted in the graduation of 17 Ph. D. and 47 M.S. students. He is an ASME Fellow, AAAS Fellow, and AIAA Associate Fellow. He has served or currently serving as an Associate Editor of the AIAA Journal, the Founding Editor of the Int. J. of Reacting Systems (now J of Combustion), and on the Editorial Boards of Journal of Green Energy, and Book Series on Sustainable Energy Developments.

Abstract

On Soot Reduction Using Oxygenated Combustion

Reduction in NOx and soot emissions from combustion systems has been a major driver for combustion research in recent years. A promising approach for reducing soot in nonpremixed flames is based on simultaneously using an O2-enriched oxidizer stream and a N2-diluted fuel stream. The effectiveness of this approach is due to the fact that it modifies the stoichiometric mixture fraction without significantly altering the adiabatic flame temperature. In this talk, we will discuss results from recent computational studies of oxygenated nonpremixed flames burning different small hydrocarbon fuels at atmospheric and high pressures. The computational model employs a validated reaction mechanism with 197 species and about 5000 reactions for gas-phase chemistry, and a fairly detailed model for soot formation and oxidation processes. Results will focus on the effect of oxygenation on the flame structure and soot emission. In addition, the talk will analyze the dominant reaction paths for the formation of first aromatic ring, i.e., benzene, which is considered a rate determining step for soot formation. The effect of pressure on the formation of polycyclic aromatic hydrocarbons (PAHs) and soot in oxygenated flames will also be discussed.

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Dr. Akshai K. Runchal is the president of Analytic and Computational Research, Inc., Bel Air, California. He obtained his PhD from Imperial College, London under the guidance of Prof. Brian Spalding in 1969. He was part of a three member pioneering group, led by Dr. Brian Spalding, that developed the finite volume method for CFD and the SIMPLE family of algorithms that are still extensively used in CFD today. Prof. Akshai Runchal has also established the CFD Virtual Reality Institute (CFDVRi), a registered non-profit, in Dharamshala, Himachal Pradesh, India. Prof. Runchal started his professional career as a faculty member at IIT Kanpur in 1969. He has taught at a number of leading institutes including IIT Kanpur, Imperial College, London, Cal Tech, Pasadena and University of California, Los Angeles. Dr. Runchal is an acknowledged and well known expert in CFD, Combustion Modeling, and performance analysis related to combustion systems. He has performed computer modeling and numerical simulation of flow, heat and mass

Abstract

Energy Efficiency via Modeling of Airflow, Thermal Comfort and Particle Transport in Hospital Ventilation Systems

This study is an attempt to improve energy efficiency and conservation via the application of CFD to the design of ventilation systems in hospitals. It is important to have an energy efficient building design to reduce energy consumption and carbon footprint. A good ventilation system will provide appropriate thermal comfort and reduce spread of airborne infections. The high accuracy of Computational Fluid Dynamics (CFD) models will help in designing ventilations systems to meet the requirements for a hospital. In this study, flow, thermal comfort and spread of airborne particles are investigated for different configurations of ventilation systems in a hospital room through the use of CFD, while attempting to maximize energy conservation.

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Abstract

Control of "Hooting" in a Gas Turbine Combustor

Aero-engines are quite noisy. The engine-induced noise can cause severe discomfort to the crew, passengers and neighbors. There has been substantial development in the mitigation of engine noise over the years. However, two sources of noise, i.e., fan noise and combustor noise, persist till date. Combustion noise, called "hooting", is due to the coupling of different modes of combustor chamber acoustics, heat release oscillations due to the inherent unsteadiness of the combustion process and the convective mode of the burned products. This study is focused on a systematic experimental program to understand the complex physics of liquid fuel combustion is a swirling flow of air, in the presence of other air streams such as quenching air, atomizing air and secondary air in a simulated gas turbine combustor. The results show strong influence of the interaction of the burned products from the primary zone and the air introduced in the secondary zone in the production of broadband noise in such systems. An effort has been made to reduce this combustion-generated noise while maintaining the global Fuel to air ratio (FAR) constant by superimposing a periodic oscillation over the mean fuel flow rate. A reduction of more than 15 dB in the SPL through this active control method was achieved. While a passive control technique of re-distribution of air flow rates among different inlets reduced the SPL by more than 20 dB. Plausible reasons for this reduction of sound pressure level are presented.

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Dr. Ashoke De is currently working as Associate Professor in the Department of Aerospace Engineering at Indian Institute of Technology Kanpur. He is the recipient of IEI-Young Engineer's Award-2014, DST Young Scientist award-2015, and P K Kelkar Research Fellowship from IIT Kanpur. He is a member of ASME, SIAM, FMFP, ISHMT and Combustion Institute. Dr. De received his Masters' degree in Aerospace Engineering from IIT Kanpur in 2004, and PhD degree in Mechanical Engineering from Louisiana State University, USA in 2009. Before joining IIT Kanpur, he has worked as post-doctoral scholar at Technical University of Delft (TU-Delft), Netherlands and as Research Engineer in GE Global research at Bangalore. Dr. De leads large scale initiatives in the modeling of turbulent reacting and non-reacting flows at IIT Kanpur. So far, he has authored more than 90 peer reviewed articles in journals and conferences. His current research interests include combustion modeling, hybrid RANS/LES model development, supersonic flows and Fluid-Structure interactions (FSI). He is actively pursuing research projects from various organizations like ISRO, ARDB, DST and PWC. His primary research focus is the emerging field of computational mechanics with particular interest in combustion and turbulent flows.

Abstract

Assessment of turbulent chemistry interaction models in no formation path ways

The present work aims to numerically investigate NOx in three turbulent piloted diffusion flames (Sandia D, E, and F) of different levels of extinction with fairly detailed chemistry, i.e. GRI 3.0 mechanism. The main focus of the study is to analyze the effects of the two different combustion model approaches, such as infinitely fast chemistry based unsteady flamelet and finite rate chemistry based EDC. The EDC approach is able to predict the passive scalar quantities but shows over-prediction in the reactive scalar quantities and NO prediction, while the unsteady flamelet modeling is found to be essential in predicting the accurate formation of slow kinetic species like NOx. The inability of flamelet and EDC approach in capturing localized flame extinction is observed, which lead to an over-prediction of NOx at larger downstream locations. Further, the dominance of NOx formation pathways is investigated in all three flames.

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From material to building: thermo-hydro-mechanical measurement and modeling of material performance and its durability

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Abstract

During the last decade, the concept of green building has become a dominant trend and the public is becoming aware of the potential environmental benefits of this alternative to conventional construction. Much of the focus of green building is on reducing a building's energy consumption (better insulation, more efficient appliances and heating, air-conditioning (HVAC) systems) and reducing harmful human health and environmentmental impacts (mold, allergy..). In fact, the hygrothermal behavior of envelopes effects on indoor comfort and the consumption of energy in building. Moreover, it depends on thermo-hydro-mechanical proprieties of building materials constituted this wall. Thus, choosing building materials that exhibit positive environmental attributes is also a major area of research. In this context, bio-based materials are becomes the subject of several studies in order to understand and characterize their thermo-hydro-mechanical behavior.

This study focuses on a new composite material consisting of two components recommended enough in the construction and in civil engineering field. It is a wood-cement concrete developed and marketed in Europe. This material was thus tested and used in a platform type of eco cottage in order to evaluate its thermo-hydro-mechanical behavior and its durability such as its resistance to fires. Indeed, this material is considered as a hygroscopic and porous media, which makes a complex system of coupled mechanisms and creates direct interactions between the heat transfer and the moisture content transport and consequently its mechanical rigidity.

Keywords: bio-based material, green building, modelling, wood-cement material, thermo-hydro-mechanical proprieties, fire resistance.

Investigation of physical and chemical composition of reclaimed municipal solid waste for using as energy source

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Abstract

Fossil fuel depression reflected by higher prices poses an obstacle to the economy of the world, especially of the non-oil producer countries. As a result, it threatens the sustainability of energy supply in the future. Therefore, this calls for efforts in finding alternative energy sources to minimize fossil fuels dependency for sustainable future use. Alternative sources of fuel considered for power generation include, but not limited to solar, wind, geothermal, tidal wave as well as biomass. Municipal solid waste (MSW) is one form of biomass. High composition of combustible materials in waste stream accounts for high-energy content of the waste. However, MSW collected directly from household without separation at source poses high moisture content and a low heating value, therefore low-grade fuel, which are not suitable for direct use as fuel in thermochemical process. In contrast, after a very long time landfilling of MSW, the organic portion in MSW is biodegraded and the high heating value combustible materials as well as non-biodegradable materials are remained. This study investigated the physical and chemical composition of reclaimed MSW at different depths and compared the results to the fresh MSW for its use as Refuse Derived Fuel (RDF). From the investigation, it is clearly seen that there are no food/fruit waste containing in reclaimed MSW because it is biodegraded during landfilling process. The reclaimed MSW has a higher content of plastic waste than fresh MSW, which leads to the higher volatile matter and higher heating value of reclaimed MSW than fresh MSW. Considering the age of MSW in landfill, it can be seen that the depth of landfill has no significant effect on the properties of reclaimed MSW. This means that after one years (at 3 m depth) the organic waste is completely decomposed. In conclusion, old MSW from landfill reclamation can be considered as an alternative energy source since it contains a high amount of combustible materials, e.g. plastic wastes. The landfill process itself behaves like the biological process to decompose organic waste in MSW, therefore only mechanical process is required for RDF production from old MSW.

Keywords: Reclaimed Municipal Solid Waste, Physical Property, Chemical Property.

Smart building envelope: for energy building efficiency

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Abstract

The building sector strongly affects the environment and generates waste and emissions of greenhouse gas and other pollutants acting on the environment and indoor air quality. In this context, a new emerging field focused in the study of combining the smart technologies and building envelope to improve the energy efficiency of building. The building envelope is mainly formed multi-layers materials with more resistant outside plaster, or wooden cladding and others more complex technique such as the green wall covered façade.

This work presents firstly an overview of the smart technologies of building envelope and its links between the climate conditions, the occupants and indoor comfort. The second part consists to analyze the best manner to manage all different parameters, variables and climate information, thermal comfort and building equipments systems, which cover two aspects; data management and business intelligence.

Keywords: Building envelope, smart technologies, thermal comfort, management.

Performance analysis of desiccant aided building cooling system

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Abstract

A simulation study on a conventional vapor compression-based building cooling system integrated with desiccant assisted dedicated outdoor air system (DOAS) is performed on warm and humid climate zone of India. In this study, the impact of using desiccant material in the DOAS, on the cooling load requirement of the building, coefficient of performance (COP), and energy consumption of the system is discussed. The building design is well-validated with the available guidelines. DOAS system provides a separated ventilation and cooling requirement to the building, which influences the performance of cooling system. Desiccant assisted system supplies dehumidified air inside the building space which affects the evaporator performance. In this study, to evaluate the effect of using desiccant on the system performance, simulations are carried out using Energy Plus software and results are compared with the conventional vapor compression-based system. A solar collector system is used to supply the hot air to regenerate the desiccant material. From the simulations results, it can be observed that for warm and humid climate zone, the usage of desiccant material in conjunction with compression-based system improves the system performance. Energy savings in desiccant assisted system can be achieved upto 5%, whereas, the COP of the system is also increased by 4%.

Keywords: building cooling, desiccant, solar collector, COP, vapour compression system.

Transient thermal analysis of a solar pond for Rupnagar city of Punjab

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Abstract

A salt gradient solar pond, which is a thermal storage device, has been modelled and analyzed for its transient state operation while subjected under the meteorological conditions of Rupnagar city of Punjab, India. The pond is considered to be of uniform rectangular cross section, and divided into three zones of decreasing salt concentration gradients. Solar radiative energy incident on the pond undergoes attritions in the top two layers of the pond, and finally reaches the bottom layer. This energy is extracted by water flowing steadily through the lower convective zone at a constant rate. The model has been well-validated with the steady-state results available in the literature for different levels of solar insolation. The governing energy equation is solved by the finite difference method involving implicit scheme for the time derivative and central differencing for the space derivative. The transient temperature distributions so attained have been studied for different mass flow rates of water flowing through the pond. By virtue of an upward salt concentration gradient, convective heat transfer of energy from the storage zone is prevented, thus allowing the system to tap useful and freely available solar energy. It is revealed from the present results that an increase in the non-convective zone thickness causes both negative and positive effects involving reduced availability of solar intensity at the storage zone, and less conductive heat losses between the storage and the upper convective zones, respectively. This permits the existence of an optimum thickness of the non-convective zone at which the pond's performance gets maximized. Thus, in this work, the efficiency of the solar pond has been evaluated at different time level against a function of the thickness of the non-convective zone. The study is proposed to be useful in designing and selecting a solar pond for thermal applications in an optimized manner ensuring the maximum output under a given meteorological condition.

Keywords: solar pond, transient thermal analysis, Rupnagar city, efficiency, temperature, finite difference method.

Effect of changing piston dimension on dynamic characteristic and performance of free-piston stirling engine

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Abstract

Free-Piston Stirling Engine (FPSE) is a Stirling cycle engine running without crank mechanism which two pistons, displacer and power piston, slide freely according to gas expansion and contraction in the hot and cold spaces. To achieve dynamic stability and smooth operation of the FPSE, all piston specifications must be analyzed by solving the equation of motions including thermodynamic principles and heater transfer. This research presents the effect of changing piston cross-sectional area on the characteristics of the FPSE. The FPSE prototype with swept volume of 40 cm3 was investigated. The engine assembled with the original and new piston cross-sectional areas of 5.81 and 16.76 cm2 was theoretically and experimentally compared. The Genetic Algorithm optimization (GA) in MATLAB toolbox was used to determine the optimum mass and spring stiffness for both piston patterns. The atmospheric air was used as the working gas which heated and cooled by electric heater and water cooler, consecutively. The acceleration and oscillating frequency of the working piston were measured by the ADXL335 accelerometer and the GOS-1052-U oscilloscope, respectively, for power computation. From the experiment, the prototype with the bigger piston cross section provided shorter stable stroke and more capability to carry heavier load than that of the engine with the smaller piston cross section.

Keywords: Free piston sterling engine (FPSE), Generic algorithm (GA), Accelerometer

Analytical and experimental investigation of variable pitch vertical axis wind turbines

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Abstract

This poster presents analytical and experimental investigation of variable pitch Vertical Axis Wind Turbines (VAWTs) which have improved efficiencies at lower tip speed ratios, works for arbitrary wind directions and can self-start at very low wind speeds. First, preliminary sizing of the VAWT model is carried out by using an analytical performance prediction tool. Next, prototypes are fabricated and instrumented based on the preliminary sizing data. Finally, the instrumented models are tested in the wind tunnel to carry out parametric study to optimize the performance of the turbine. The preliminary experimental test shows these models scale turbines are efficient and self-starting at low wind speeds which making them ideal for standalone operation in rural and urban settings where the average annual wind speed may be low. These turbines exhibit higher efficiency at lower wind speeds and turbulent wind profile when compared to Horizontal Axis Wind Turbine (HAWT) and fixed pitch VAWT designs. Lower footprint in terms of space required for operation also make them ideal for use in high density wind energy farms. The current research involving design and development of an efficient variable pitch vertical axis wind turbine aims to address the challenge of improving electricity access to rural and urban homes in an environment friendly manner. The data obtained during the experiments would be used to further refine the analytical performance prediction tool.

Keywords: Wind turbine, Renewable energy, Analytical and Experimental Investigation, Variable pitch turbine.

Analytical and experimental investigation of variable pitch vertical axis wind turbines

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Abstract

This work focuses on the combustion instability caused in a half-dump combustor. In this type of combustor the main reason of combustion instabilities is the coupling mechanisms between unsteady combustion processes and acoustic waves propagating in the ducts where the combustion takes place. These coupling mechanisms are the central issues in the development of many modern combustion systems because of both environmental issues (noise) and the destructive interactions with acoustics generated in combustors. Even when flames are not subjected to strong combustion instabilities, acoustic waves interact with turbulent combustion in a number of situations and can modify flames as significantly as turbulence. Hence, a study is carried out on the non-premixed methane air half-dump combustor at higher and lower Reynolds number. GRI-3.0, a multi-step, detailed reaction mechanism is used for solving non-premixed methane air combustion. The natural acoustic modes of the duct or some hydrodynamic phenomena are primarily the source of unsteady pressure signal. High Reynolds number simulation have shown the lock-on achieved between combustion process (heat release) and the acoustic waves whereas low Reynolds number witness acoustically stable combustion and the hydrodynamics is being the primary source of pressure fluctuation.

Keywords: combustion instability, half-dump combustor.

Soot formation in high pressure kerosene/air turbulent diffusion flame

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Abstract

Soot is a byproduct of combustion. In the present study Soot formation in Kerosene diffusion flame at elevated pressure is investigated. Four different pressures ranging from 1 bar to 4.81 bar is considered for investigation. Chemical kinetics is implemented using two different mechanisms such as POLIMI (Ranzi et al. 2014) and JetFuelSurrugate (Narayanaswami et al. 2016) mechanisms. Flow field is solved using Reynolds Stress Model (RSM) and steady laminar flamelet model (SLFM) is used to model the turbulence-chemistry interaction. The medium is assumed to be non-gray and weighted sum of gray gas model (WSGGM) is used to find the absorption coefficient of radiative participating medium. Soot formation is modelled using two different approaches, i.e. semi-empirical two-equation models (MBH) and Quadrature methods of moments (MOM) with first three moments are used and both the approaches consider various sub-processes such as nucleation, coagulation, surface growth and oxidation. The Co-flow diffusion flame configuration as in Young et al. (1994) is considered for the assessment of these soot models. The centerline and radial soot volume fraction is reproduced and Moss Brookes Hall model (MBH) is in good agreement with the experimental results.

Keywords: Soot Formation, diffusion flame, elevated pressure

A binary fuel approach as an alternative to fossil fuel use in compression-ignition engines

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Abstract

With the socio-economic growth, the need of energy is increasing as it is one of the crucial factor for the development. The dominating necessities of fossil based products along with its adverse impacts on the environment have generated alarming conditions. Transportation sector is the leading user of energy and largely based on diesel fuel. Hence, the need of more diversified research in alternate sources arises, even to the point of complete elimination of diesel from compression-ignition (CI) engines. It is possible to use binary fuel blends (blended mixture of low and high viscous fuel) in CI engines. Blends of biodiesel-oil offers one of the feasible way. Using methyl ester in various proportions with edible and non-edible oils have the capability to give a stable solution and can be used as a fuel in CI engines. The mixing of two fuels blending considerably improves the physicochemical properties of the blend, as the inferior properties of one biofuel remunerates from improved properties of the other fuel. The present study provides comprehensive information on the emission and performance characteristics of binary biodiesel- oil fuel blends. Most researchers had suggested optimum blends from their respective studies that support capability for complete elimination of diesel from CI engines. The researchers are working in the area of alternate fuel for engines often focus on achieving higher efficiency, reduced emissions, and energy conservation. As only one third of the total power generated is used as output power, while the two-thirds are wasted, this, in turn, consists of one third in the coolant and the remaining to the exhaust. The most important parameter, however, is the air-fuel mixing and a way to improve this is to alter the engine parameters in case of biodiesel and its blends. In this regard, some researchers have used this binary fuel blend with minor adjustments to the engine parameters. These investigations have provided positive results. Tribological performance of these binary fuel blends has also been studied. All these prospects and their impacts on engine life and environment are discussed in this study. The comprehensive review concluded that binary fuel approach has potential to completely eliminate diesel from CI engines.

Keywords: Binary fuel blends, Emissions, Fossil fuel replacement, Performance analysis

Effect of burner diameter on flame structure and stability of co-flow laminar diffusion flames of diluted methane fuel

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Abstract

Efficient use of Low Calorific Value Gases (LCVG), such as those obtained from in-situ combustion during enhanced oil recovery, is a challenge. LCVG is abundantly available in gasification of coal, wood and bio-mass and by-products of a number of industrial processes. Sometimes, these gases are just flared after mixing the gas with natural gas. Obviously, it is desirable to find better use of these gases incorporating a sound combustion strategy to harness their calorific value. Therefore, exclusive studies of LCVG combustion can contribute significantly to the development of an efficient eco-friendly technology. LCVG is defined as a mixture of combustible gases (CO, H2 and CH4), inert gases (N2 and CO2) and non-hydrocarbon impurities (H2S, NH3 and so on) having a heating value below 7 MJ/m^3.

With these motivations, the current research work has been initiated to study the flame structure and stability of nitrogen and helium diluted methane fuel when it is burned in oxygen-enhanced environment in laminar co-flow diffusion combustion mode. Wide ranges of experiments are planned to perform in order to investigate the flame structure/triple flame structure and stability aspects of these LCVG combustion. So far a complete set of experiments for all four varying parameters are performed using nitrogen as a diluent in methane fuel at burners of 4 and 9-mm diameter. In future, the set of experiments are also required to perform using Helium as a diluent for identical design of experiments.

Keywords: Flame structure, Flame stability, Diffusion flames, Nitrogen and helium diluted methane flame, Low calorific value gases

Development of colorless distributed combustion for high intensity gas turbines

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Abstract

There is a growing need to improve current combustion technologies, developing new and innovative techniques which seek near zero emissions, enhanced performance, and longer operational lifetime. These methods should furnish a wide dynamic range of operation along with uniform temperature profiles in order to reduce the engine heat load promoting enhanced stability, increased efficiency, energy savings, and ultra-low pollutant emissions. Colorless Distributed Combustion (CDC), is one such novel combustion method wherein combustion is distributed over the entire volume of the combustor instead of being concentrated in a thin reaction sheet. In achieving distributed combustion relies heavily on mixture preparation. The fresh air stream is mixed with hot reactive gases from within the combustion zone in order to form a low oxygen concentration, high temperature, distributed mixture for spontaneous ignition and distributed reaction throughout the combustor volume. Achieving these distributed reactions results in lower reaction rates over a large volume resulting in the same fuel consumption of standard combustion (high reaction rates over a small reaction zone). In design for novel combustion methods for gas turbine application, it is important to have increased stability, low emissions, and fuel flexibility. The mitigation of hot spots in the combustor improves combustion stability as well as lifetime. In addition, NOx mitigation through reduction in peak temperatures associated with NOx formation according with the Zeldovich mechanism, in order to obtain near unity ppm NOx even at near stoichiometric conditions. In order to reduce other pollutants, such as CO and unburnt hydrocarbons, lower equivalence ratios shall be used to ensure complete combustion. Current efforts on designing CDC for gas turbines utilize a swirl burner for development of a single can gas turbine combustor. Investigations thus far have shown increased combustion stability, excellent fuel flexibility, and significant pollutant emission reduction.

Keywords: Colorless distributed combustion (CDC), High intensity combustion, Gas turbine combustion, Near zero emission, Fuel flexibility, Combustion stability

Synergistic effects in co-pyrolysis of biomass and plastic wastes

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Abstract

Energy recovery from wastes, also called the Waste-to-Energy (WTE), is of pinnacle importance for renewable and sustainable energy development. Dry gasification can be used to transform solid wastes into fuel gases/liquids and chemicals along with the added advantage of CO2 utilization. Dry (CO2) gasification of combined biomass and plastics at different mass ratios of biomass to plastic is investigated in TGA-DSC at atmospheric pressure using different types of plastics. Effect of temperature, heating rate, the presence of CO2, and the plastic content on the reaction characteristics will be examined. The specific thermoplastics examined were: black polycarbonate (BPC), polyethylene-terephthalate (PET), and polypropylene (PP). The observed synergy is quantified from a direct comparison of (differential thermogravimetry) DTGs from biomass-plastics mixtures to the corresponding weighted aggregate results from the gasification of separate feedstock components. Multiple reaction pathway based models will be inverse fitted to these experimental results to obtain activation energy and kinetic pathway based comparison to determine the effect of blending biomass with different types of plastics on the pathway undertaken by the reactants. This investigation will provide mathematically quantified insight into the requirements for synergy and the extent of synergistic effects which are required to make synergy utilized multi-component and feed flexible gasification possible.

Keywords: Waste to energy, Dry (CO2) gasification, Biomass-plastic wastes, Polyethylene, Polypropylene, Black polycarbonate, Thermogravimetric analysis, Synergistic effects.

Effect of H_2 enrichment on the laminar burning velocity and flame stability of various multicomponent natural gas blends

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Abstract

Unstretched laminar burning velocity (LBV) is an essential fundamental property in premixed combustion. In a spherically expanding flame configuration, the flame experiences stretch, thereby affecting LBV. In the present work, H2 is blended with various natural gas (NG) blends to enhance the combustion properties. Effect of variation of H2 content on unstretched LBV and burned gas Markstein Length (Lb) have been experimentally evaluated using a constant pressure spherically expanding flame configuration and by implementing suitable stretch correction. All the experiments are performed at an initial temperature of 300 ± 3 K, 0.1 MPa pressure and for a range of equivalence ratios, $\Phi = 0.6$ to 1.4.

The addition of H2 enhances the combustion chemistry of all the NG blends and hence, increases the LBV. However, the effect is more prominent for the blend which has a higher mole fraction of CH4. The NG-H2 blend which has a higher mole fraction of C3H8 maintains a positive Lb for a wider range of equivalence ratio (0.7 to 1.4).

Keywords: Laminar Burning Velocity, Natural gas, H2 Enrichment, Spherically expanding flame

Effect of a magnetic field on heat transfer in phase-change-material-based thermal storage device

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Abstract

Thermal heat storage devices are frequently used to store and deliver energy for heat and power applications. In these devices, thermal energy is stored as a latent or sensible heat. Among them, latent-heat based storage devices found to have higher heat transfer efficiency. This is achieved by the use of phase-change materials (PCMs), for example: gallium, sodium nitrate, potassium nitrate, etc. However, the heat transfer efficiency is less for the low thermal conductivity PCMs. To improve the efficiency of PCM-based thermal storage devices, various techniques are being used, such as, use of fins, use of multiple PCMs, use of heat pipes, and enhancing the thermal conductivity by adding nano-particles. It is well-known that the efficiency can also be increased by enhancing the convection and rate of solidification and melting. Magnetic fields have been found to have an effect on the fluid flow behavior and, therefore, on the heat transfer. In this work, 2D unsteady numerical simulations, using ANSYS-Fluent with the enthalpy-porosity formulation, are performed to study an effect of a uniform transverse magnetic field on heat transfer inside a cavity filled initially with solid gallium. The horizontal walls of the cavity are considered insulated and vertical walls are, respectively, considered hot and cold. The magnetic field is characterised by the Hartmann number (Ha) and the results are shown for the Ha = 0, 30 and 50. It is observed that, with the increase in the transverse uniform magnetic field, the rate of melting of gallium and the heat transfer rate decreases.

Keywords: Magneto-hydrodynamics, PCM-based thermal energy storage devices, CFD simulations.

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