

# 2016 University Turbine Systems Research Project Review Meeting



November 1-3, 2016 • Blacksburg, Virginia

Co-Organized by:





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## ABOUT THE 2016 UTSR WORKSHOP

The National Energy Technology Laboratory University Turbine Systems Research (NETL-UTSR) program manages a portfolio of university-based turbine research projects. The UTSR program offers a Gas Turbine Industrial Fellowship funded by sponsoring gas turbine manufacturers. This fellowship has helped to facilitate the transition of the best students from academia to the gas turbine industry, thereby helping to maintain U.S. leadership in this important area of technology.

The success of the UTSR program has been made possible by a network of universities, the collaborating gas turbine industry, and the DOE turbine program—all of which are facilitated by an annual UTSR project review meeting—which is open to the public and brings together experts from academia, industry, and government to present and discuss ongoing turbine research sponsored by the DOE Office of Fossil Energy UTSR program under existing cooperative agreements.

The UTSR program chooses meeting venues that are in close proximity to leading universities directly involved in turbine research. In 2016, the UTSR project review meeting is being held at the Inn at Virginia Tech and Skelton Conference Center, near the Virginia Tech campus in Blacksburg, Virginia. This will allow for tours of the following Virginia Tech facilities: the Advanced Propulsion and Power Lab, the Turbo Lab, the Stability Wind Tunnel Lab and the Goodwin Hall (the flagship building for the College of Engineering). This year's meeting theme is "Advanced Diagnostics for Modern Gas Turbine Engines." There will be two keynote speakers: Dr. Gregory Strouse and Dr. Madhav Marathe. Dr. Strouse, Associate Director for Measurement Services of the Physical Measurement Laboratory (PML) at the National Institute of Standards and Technology (NIST), is a leading expert in temperature measurement and the realization and dissemination of the International Temperature Scale of 1990 (ITS 90). He has designed and built up several new world-class facilities including laboratories for the calibration of standard platinum resistance thermometers, thermocouples, and industrial thermometers.



# ABOUT THE 2016 UTSR WORKSHOP

Dr. Marathe, Director of the Network Dynamics and Simulation Science Laboratory at the Biocomplexity Institute of Virginia Tech, was a Team Leader in the Computer and Computational Sciences division at the Los Alamos National Laboratory where he led the basic research programs in foundations of computing and high performance simulation science for analyzing extremely large socio-technical and critical infrastructure systems. The meeting will feature two panels which will focus on advanced diagnostics for modern gas turbine engines and related university-industry collaborative models to address the R&D needs and challenges. The meeting will include three technology tracks: Combustion/Pressure Gain Combustion, Aero/Heat Transfer/Supercritical CO<sub>2</sub>, and Materials. The meeting will also include a majority of NETL's extramural projects for the Advanced Turbines Program as well as internal NETL R&D projects. The meeting will feature approximately 60 DOE sponsored projects in the form of oral and poster presentations. There will also be a special after-dinner presentation by Dr. Tom Dingus, Director of the Virginia Tech Transportation Institute (VTTI). Dr. Dingus was named a White House Champion of Change and was selected for his exemplary leadership in developing or implementing transportation technology solutions. He is a Fellow of the Human Factors and Ergonomics Society (HFES), from which he has received several awards, including the A.R. Lauer Award for outstanding contributions to the field of safety.



## UTSR TECHNOLOGY SUMMARY

Since the inception of the DOE turbine program, the NETL-UTSR program has sought to support the underlying scientific research necessary to develop advanced turbines and turbine-based systems in support of the DOE's turbine program's strategic goals and program mission needs. This is accomplished by funding university-based research projects that address scientific R&D as well as technical challenges in turbine-based systems and technology. This research focuses on the fundamental and applied issues associated with advancing the performance and efficiency of turbines in fossil fuel power generation beyond current state-of-the-art. Technical areas of interest include combustion, aerodynamics, heat transfer, materials, technology development for supercritical carbon dioxide based power cycles, pressure gain combustion, and oxy-fuel turbine based systems and technology.

The projects are typically three years in duration and focus on applied laboratory/bench scale R&D. Currently 12 universities and 18 projects are involved in the NETL-UTSR program. The innovations and scientific understanding generated under this program will then be transferred to industry manufacturers for incorporation into their next generation turbine technology products with the goal of producing reliable, affordable, clean, efficient, and cost-effective energy supplies.

One of the main purposes of this UTSR project review meeting is to facilitate peer-to-peer knowledge sharing and collaboration across boundaries so as to create a network of expertise and facilitate the acceleration of advancements in those fields.



## UTSR INDUSTRY COMMITTEE

**John Alday** – FlexEnergy  
**Klaus Brun** – Southwest Research Institute  
**Jim Downs** – Florida Turbine Technologies  
**Michael Fox** – Solar Turbines, Inc.  
**Ken Hall** – Siemens Power Generation, Inc.  
**Kathryn Rominger** – General Electric



## ORGANIZING COMMITTEE

**Klaus Brun** – Southwest Research Institute  
**Patcharin (Rin) Burke** – U.S. Department of Energy,  
National Energy Technology Laboratory  
**Bill Day** – KeyLogic  
**Richard Dennis** – U.S. Department of Energy,  
National Energy Technology Laboratory  
**Srinath Ekkad** – Virginia Tech  
**Karen Lockhart** – SSC Deltha  
**Heather Quedenfeld** – U.S. Department of Energy,  
National Energy Technology Laboratory



# LABORATORY TOUR

Lab tours will involve visits to four different facilities on Virginia Tech campus.

- The Virginia Tech Advanced Propulsion and Power Lab is located on the Corporate Research Center campus in Blacksburg. It is a 8,100 square foot lab facility with 6 unique test cells for conducting research from TRL 0-6. Several unique test rigs including the Aerothermal Rig, Optical Combustor Rig, Rotating Internal Cooling Rig, Large Scale Rotor Rig, Hot Jet Facility, Hypersonic rig, and small turbine engine test facility. The lab has 5 core faculty and over 40 graduate and undergraduate students working on various projects funded by industry and federal agencies.
- The Turbo lab is located at the Virginia Tech Airport. There are 3 test cells for small engine testing. There are currently 2 P&W JT15Ds and Honeywell TFE731-2 engines at the test facility in addition to a P&W PT6 Turboshaft engine. The lab is directed by Dr. Walter O'Brien.
- The Stability Wind Tunnel is operated by the Aerospace and Ocean Engineering Department. With a 1.83m-by-1.83m test-section, it is one of the largest university operated wind tunnels in the United States with maximum speeds of 80m/s (corresponding to a Reynolds number of 5,000,000 per meter). In addition to its size, the flow quality is remarkable making it a prime research facility. The aerodynamic capabilities were recently increased by the addition of a removable anechoic test-section allowing for full-scale aero-acoustic testing. Since May, 2004, the facility has been under the direction of Dr. William Devenport, and currently employs one full time test engineer and several part time student employees.
- Goodwin Hall is the flagship building for the College of Engineering. It houses 40 instructional and research labs, 8 classrooms, the Quillen Family Auditorium, and 150 offices for several engineering departments. A Rolls-Royce Trent 1000 engine hangs in the atrium with software for students and visitor to try to design jet engines for fun. The engine was provided by Rolls-Royce for display to strengthen their commitment to the relationship with Virginia Tech. More than classrooms, offices, and laboratories, Goodwin Hall is a ground-breaking experiment to measure even the smallest vibrations made inside the building.

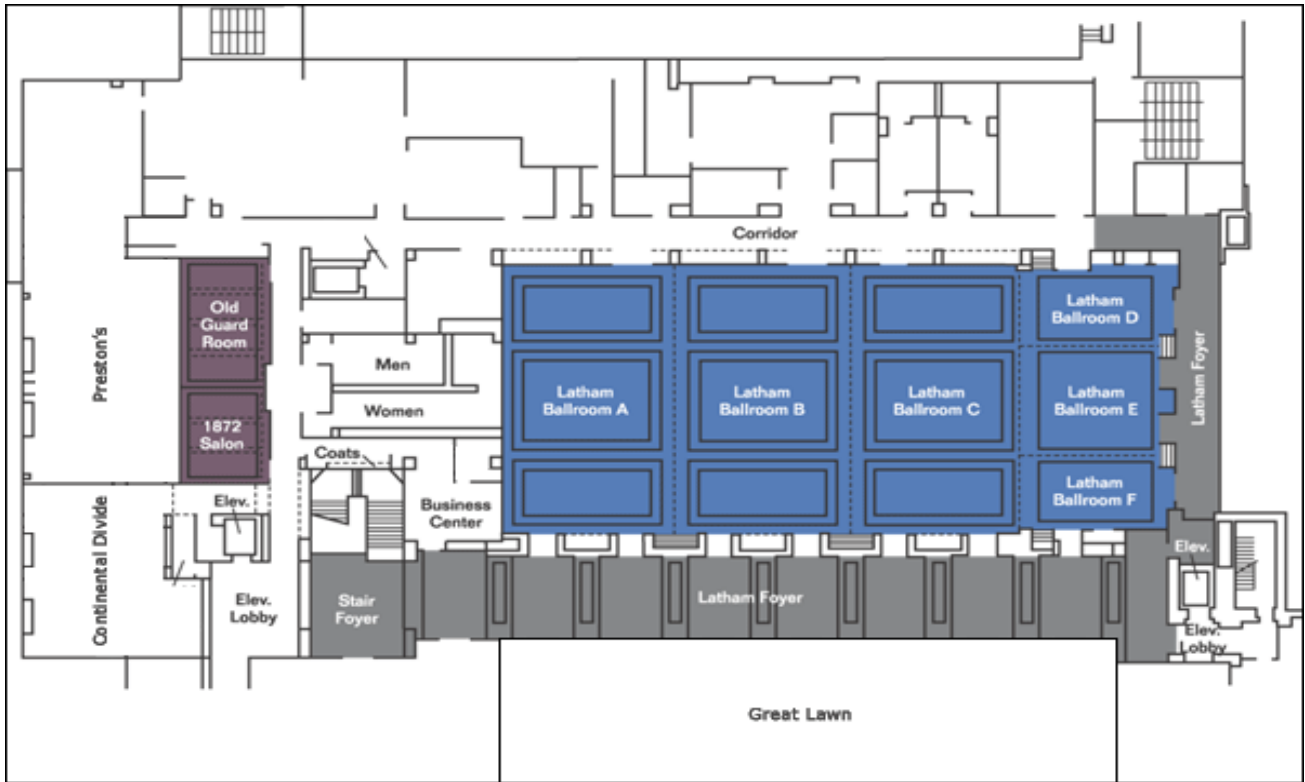


# AGENDA AT-A-GLANCE

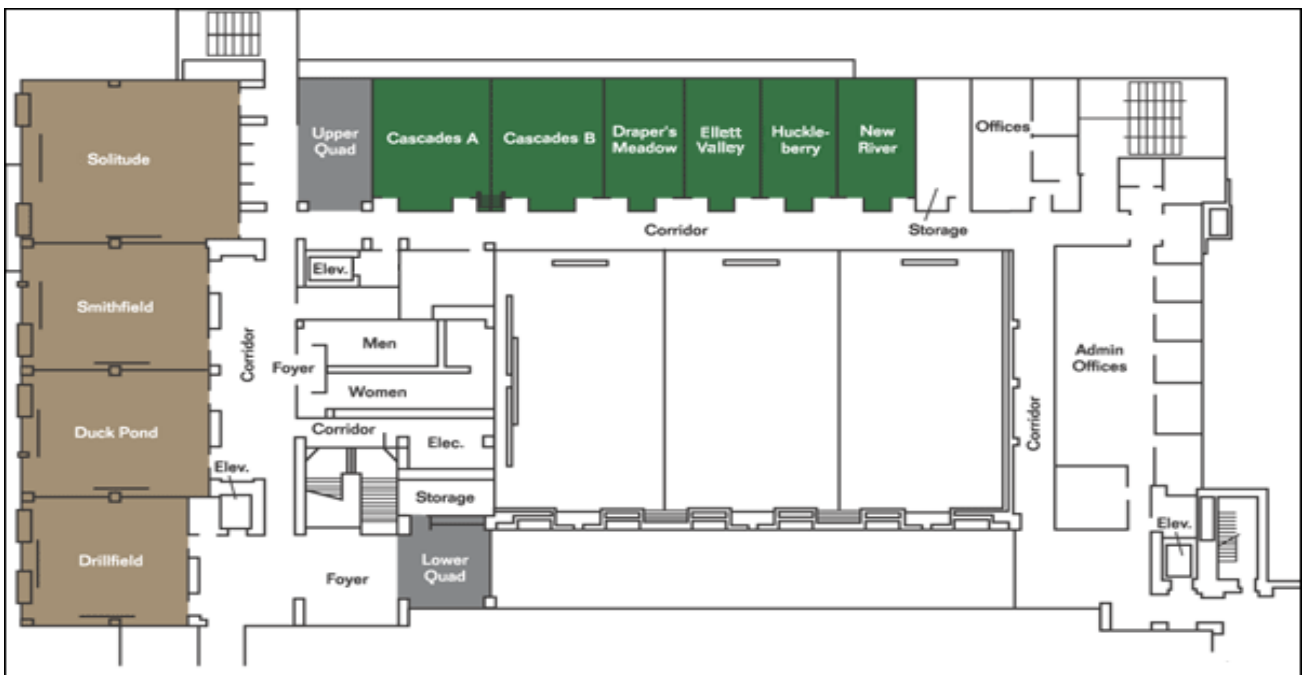
Day/Time	Track 1-Combustion & Pressure Gain Combustion	Track 2-Aero/Heat Transfer/sCO2	Track 3- Materials
<b>Tuesday, November 1, 2016</b>			
Tues, 7:00 am	Registration/Continental Breakfast - Latham Foyer		
	General Session - Latham A&B		
Tues, 8:00 am	Welcome and Introduction - Theresa Mayer, VP for Research and Innovation, Virginia Tech		
Tues, 8:10 am	Opening Remarks - Richard Dennis, Advanced Turbines Technology Manager, NETL		
Tues, 8:20 am	Panel Discussion: Advanced Diagnostics for Modern Gas Turbine Engines: Challenges and Opportunities (NETL-Robert Romanosky; RR-Pete Loftus; GE-Jason Dees; NIST-Greg Strouse; EPRI-Susan Maley; Siemens Energy, Inc.-Paul Zombo)		
Tues, 9:50 am	Coffee Break - Latham Foyer		
Tues, 10:20 am	Key Note Presentation - Gregory Strouse, NIST		
Tues, 10:50 am	Panel Discussion: University-Industry Collaborative Models (VT-Srinath Ekkad; Purdue-Stephen Heister; Penn State-Karen Thole; P&W-Atul Kohli; Solar Turbines-Doug Rawlins; RR-Pete Loftus)		
Tues, 12:20 pm	Lunch - Latham A&B		
Tues, 1:30 pm	Overview of DOE Advanced Turbines Program - Richard Dennis, Advanced Turbines Technology Manager, NETL		
	Smithfield Room	Solitude Room	Cascades Room
	Moderator: Mark Freeman and Donald Ferguson	Moderator: Robin Ames and Steve Richardson	Moderator: Rin Burke
	Combustion	Aero/Heat Transfer	Materials
Tues, 2:00 pm	GE Power - Michael J. Hughes	Pennsylvania State University - Karen Thole	Siemens Energy, Inc. - Jonathan Shipper
Tues, 2:45 pm	Georgia Institute of Technology -Tim Lieuwen	University of Pittsburgh-Minking Chyu and West Virginia University-Bruce Kang	GE Power - John Delvaux
Tues, 3:30 pm	Coffee Break - Latham Foyer		
Tues, 4:00 pm	Pennsylvania State University - Jacqueline O'Connor	University of North Dakota - Forrest Ames and Illinois Institute of Technology - Sumanta Acharya	Purdue University - Thomas Siegmund
Tues, 4:45 pm	University of South Carolina -Tanvir Farouk	National Energy Technology Laboratory -Can Selcuk Uysal and Sridharan Ramesh	Georgia Insitute of Technology - Rick Neu
Tues, 5:30 pm	Lab Tour (Virginia Tech)		
Tues, 7:00 pm	Poster Session - Latham C-F		
<b>Wednesday, November 2, 2016</b>			
Wed, 7:00 am	Registration - Latham Foyer - Continental Breakfast - Latham Foyer		
	General Session - Latham A&B		
Wed, 8:00 am	Key Note Presentation: Madhav Marathe, Director of NDSSL, Virginia Tech		
	Smithfield Room	Solitude Room	Cascades Room
	Moderator: Mark Freeman and Donald Ferguson	Moderator: Robin Ames and Steve Richardson	Moderator: Rin Burke
	Combustion	Aero/Heat Transfer	Materials
Wed, 8:45 am	University of Michigan - Margaret Wooldridge	Virginia Tech. - Sandeep Kudukodi, Suhyeon Park and Siddhartha Gadiraju	University of California, Irvine - Daniel Mumm
Wed, 9:30 am	University of Michigan - Venkat Raman	Purdue University - Tom Shih	ORNL - Bruce Pint
Wed, 10:15 am	Coffee Break - Latham Foyer		
Wed, 10:45 am	Texas A&M -Eric Petersen	The Ohio State University - Jeffrey Bons	Mikro System - John R. Paulus
Wed, 11:30 am	Purdue University - Robert P. Lucht, J.P. Gore and Princeton University - Michael E. Mueller and Yiguang Ju	Florida Turbine Technologies, Inc. - Neil Kant	University of Connecticut and Solution Spray Technologies LLC -Eric Jordan
Wed, 12:15 pm	Lunch - Latham A&B		
	Pressure Gain Combustion	Supercritical CO2	Materials
Wed, 1:30 pm	Oregon State University - David L. Blunck	General Electric Global Research - Jason Mortzheim	UES, Inc. - Amarendra K. Rai and Pennsylvania State University - Douglas E. Wolfe
Wed, 2:15 pm	University of Michigan - Mirko Gamba	Southwest Research Institute - Jacob Delimont	Questek Innovations LLC - James Saal
Wed, 3:00 pm	Pennsylvania State University - Richard A. Yetter	Thar Energy, LLC -Marc Portnoff	Direct Vapor Technologies - Derek Hass
Wed, 3:45 pm	Coffee Break - Latham Foyer		
Wed, 4:15 pm	Purdue University - Carson Slabaugh	Georgia Institute of Technology - Wenting Sun	
Wed, 5:00 pm	National Energy Technology Laboratory - Don Ferguson	University of Central Florida - Subith Vasu	
Wed, 5:45 pm	Aerojet Rocketdyne - Scott Claflin	Mechanical Solution - Peter A. Chapman, Jr.	
Wed, 7:00 pm	Dinner / Dinner Speaker: Overview of VTTI Activities - Tom Dingus, Director of Virginia Tech Transportation Institute - Latham A&B		
<b>Thursday, November 3, 2016</b>			
Thur, 8:00 am	Continental Breakfast - Latham Foyer		
	General Session - Latham A&B		
Thur, 8:45 am	UTSR Fellowship Program - Bill Day, KeyLogic		
Thur, 9:00 am	The Future of UTSR in 2017 - Richard Dennis, Advanced Turbines Technology Manager, NETL		
Thur, 11:00 am	Open Discussion, Workshop Summary, Closing Comments, and Wrap-up - Richard Dennis, Advanced Turbines Technology Manager, NETL		
Thur, 11:30 pm	Adjourn		

# SKELTON CONFERENCE CENTER FLOOR PLAN

## FIRST FLOOR



## SECOND FLOOR



# DETAILED PROGRAM

**TUESDAY, NOVEMBER 1**

## **REGISTRATION / CONTINENTAL BREAKFAST**

**7:00 AM -- Latham Foyer**

## **WELCOME AND INTRODUCTION -- Latham A&B**

**8:00 AM -- Theresa Mayer, Vice President for Research and Innovation, Virginia Tech**

## **OPENING REMARKS -- Latham A&B**

**8:10 AM -- Richard Dennis, Advanced Turbines Technology Manager, U.S. Department of Energy, National Energy Technology Laboratory**

## **PANEL DISCUSSION: ADVANCED DIAGNOSTICS FOR MODERN GAS TURBINE ENGINES: CHALLENGES AND OPPORTUNITIES**

**8:20 AM -- Latham A&B -- Moderator: Srinath Ekkad, Virginia Tech**

*Robert Romanosky, National Energy Technology Laboratory*

*Pete Loftus, Rolls Royce plc*

*Jason Dees, GE Global Research*

*Greg Strouse, NIST*

*Susan Maley, EPRI*

*Paul Zombo, Siemens Energy, Inc.*

**9:50 AM -- COFFEE BREAK -- Latham Foyer**

## **10:20 AM KEYNOTE PRESENTATION -- Latham A&B**

*Thermodynamic Miniaturized Sensors and Standards and the Quantum SI*  
*Gregory Strouse, NIST*

## **PANEL DISCUSSION: UNIVERSITY-INDUSTRY COLLABORATIVE MODELS**

**10:50 AM -- Latham A&B -- Moderator: Richard Dennis, Advanced Turbines Technology Manager, U.S. Department of Energy, National Energy Technology Laboratory**

*Srinath Ekkad, Virginia Tech*

*Stephen Heister, Purdue University*

*Karen Thole, Pennsylvania State University*

*Atul Kohli, Pratt & Whitney*

*Douglas Rawlins, Solar Turbines Incorporated*

*Pete Loftus, Rolls Royce plc*

**12:20 PM -- LUNCH -- Latham A&B**

**1:30 PM -- Overview of the U.S. Department of Energy's Advanced Turbines Program - Latham A&B**

*Richard Dennis, Advanced Turbines Technology Manager,  
U.S. Department of Energy, National Energy Technology Laboratory*

**Combustion & Pressure Gain Combustion (Track 1) -- Smithfield Room**

**Moderator: Mark Freeman and Donald Ferguson,  
U.S. Department of Energy, National Energy Technology Laboratory**

# DETAILED PROGRAM

**TUESDAY, NOVEMBER 1**

**2:00 PM** -- *Advanced Multi-Tube Mixer Combustion for 65% Efficiency*  
Michael Hughes, GE Power

**2:45 PM** -- *High Temperature, Low  $NO_x$  Combustor Concept Development*  
Tim Lieuwen, Georgia Institute of Technology

**3:30 PM** -- **COFFEE BREAK -- Latham Foyer**

**4:00 PM** -- *Understanding Transient Combustion Phenomena in Low- $NO_x$  Gas Turbines*  
Jacqueline O'Connor, Pennsylvania State University

**4:45 PM** -- *An Experimental and Modeling Study of  $NO_x$ -CO Formation in High Hydrogen Content Fuels Combustion in Gas Turbine Applications*  
Tanvir Farouk, University of South Carolina

**Aero/Heat Transfer/ $sCO_2$  (Track 2) -- Solitude Room**

**Moderator:** Robin Ames and Steve Richardson, U.S. Department of Energy, National Energy Technology Laboratory

**2:00 PM** -- *START: Turbine Rim Seal Results and Next Steps*  
Karen Thole, Pennsylvania State University

**2:45 PM** -- *Design, Fabrication, and Performance Characterization of Near-Surface Embedded Cooling Channels (NSECC) with an Oxide Dispersion Strengthened (OSD) Coating Layer*  
Minking Chyu, University of Pittsburgh  
Bruce Kang, West Virginia University

**3:30 PM** -- **COFFEE BREAK -- Latham Foyer**

**4:00 PM** -- *Thermally Effective and Efficient Cooling Technologies for Advanced Gas Turbines*  
Sumanta Acharya, Illinois Institute of Technology  
Forrest Ames, University of North Dakota

**4:45 PM** -- *Thermodynamic Model to Quantify the Impact on Cooling Improvements on Gas Turbine Efficiency*  
Can Selcuk Uysal, U.S. Department of Energy, National Energy Technology Laboratory

*Film Cooling Experiments at Near Engine Conditions*  
Sridharan Ramesh, U.S. Department of Energy, National Energy Technology Laboratory

**Materials (Track 3) -- Cascades Room**

**Moderator:** Rin Burke, U.S. Department of Energy, National Energy Technology Laboratory

**2:00 PM** -- *Ceramic Matrix Composite Advanced Transition for 65% Combined Cycle*  
Jonathan Shipper, Siemens Energy, Inc.

**2:45 PM** -- *High-Temperature Ceramic Matrix Composite (CMC) Nozzles for 65% Efficiency*  
John Delvaux, GE Power





# DETAILED PROGRAM

**TUESDAY, NOVEMBER 1**

**3:30 PM -- COFFEE BREAK -- Latham Foyer**

**4:00 PM -- *Creep-Fatigue Interaction in IN 718***  
*Thomas Siegmund, Purdue University*

**4:45 PM -- *Microstructure Sensitive Crystal Viscoplasticity for Ni-base Superalloys***  
*Richard Neu, Georgia Institute of Technology*

**5:30 PM -- Lab Tour -- Virginia Tech**

**7:00 PM -- Poster Session -- Latham Foyer C-F**

# DETAILED PROGRAM

**WEDNESDAY, NOVEMBER 2**

## **REGISTRATION / CONTINENTAL BREAKFAST**

**7:00 AM -- Latham Foyer**

## **GENERAL SESSION -- Latham A&B**

**8:00 AM KEYNOTE PRESENTATION -- Latham A&B**

*Informatics and Analytics for Integrated Energy Systems*

*Madhav Marathe, Director of NDSSL, Virginia Tech*

## **Combustion & Pressure Gain Combustion (Track 1) -- Smithfield Room**

**Moderator:** *Mark Freeman and Donald Ferguson, U.S. Department of Energy, National Energy Technology Laboratory*

**8:45 AM -- Final Report on Fundamental Studies to Enable Robust, Reliable, Low Emission Gas**

*Turbine Combustion of High-Hydrogen Content Fuels*

*Margaret Wooldridge, University of Michigan*

**9:30 AM -- Joint Experiments/Simulations of Flame Propagation in Stratified Mixtures**

*Venkat Raman, University of Michigan*

**10:15 AM -- COFFEE BREAK -- Latham Foyer**

**10:45 AM -- High Pressure Turbulent Flame Speeds and Chemical Kinetics of Syngas Blends With and Without Impurities**

*Eric Petersen, Texas A&M University*

**11:30 AM -- Effects of Exhaust Gas Recirculation on Turbulent Combustion and Emissions in Advanced Gas Turbine HHC Fuels**

*Robert Lucht and Jay Gore, Purdue University,*

*Yiguang Ju and Michael Mueller, Princeton University*

**12:15 PM -- LUNCH -- Latham A&B**

**1:30 PM -- Development of a Pressure Gain Combustion System for Power Extraction using Magnetohydrodynamics**

*David Blunck, Oregon State University*

**2:15 PM -- A Joint Experimental/Computational Study of Non-Idealities in Practical Rotating Detonation Engines**

*Mirko Gamba, University of Michigan*

**3:00 PM -- The Effect of Mixture Concentration Inhomogeneity on Detonation Properties in Pressure Gain Combustion**

*Richard Yetter, Pennsylvania State University*

**3:45 PM -- COFFEE BREAK -- Latham A&B**

**4:15 PM -- Advancing Pressure Gain Combustion in Terrestrial Turbine Systems**

*Carson Slabaugh, Purdue University*

**5:00 PM -- Overview of Rotating Detonation Engine Performance at the National Energy Technology Laboratory**

*Don Ferguson, U.S. Department of Energy, National Energy Technology Laboratory*

**5:45 PM -- Rotating Detonation Combustion for Gas Turbines**

*Scott Claffin, Aerojet Rocketdyne*

# DETAILED PROGRAM

## WEDNESDAY, NOVEMBER 2

### **Aero/Heat Transfer/sCO<sub>2</sub> (Track 2) -- Solitude Room**

**Moderator:** *Robin Ames and Steve Richardson, U.S. Department of Energy, National Energy Technology Laboratory*

**8:45 AM** -- *Evaluation of Flow and Heat Transfer Inside Lean Pre-Mixed Combustor Systems Under Reacting Flow Conditions*  
*Sandeep Kedokodi, Suhyeon Park, and Siddhartha Gadiraju, Virginia Tech*

**9:30 AM** -- *RANS and LES of Turbine Heat Transfer*  
*Tom Shih, Purdue University*

### **10:15 AM -- COFFEE BREAK -- Latham Foyer**

**10:45 AM** -- *Revolutionizing Turbine Cooling with Micro-Architectures Enabled by Direct Metal Laser Sintering*  
*Jeffrey Bons, The Ohio State University*

**11:30 AM** -- *Air Riding Seal Technology for Advanced Gas Turbine Engines*  
*Neil Kant, Florida Turbine Technologies, Inc.*

### **12:15 PM -- LUNCH -- Latham A&B**

**1:30 PM** -- *Low-Leakage Seals for Utility-Scale sCO<sub>2</sub> Turbines*  
*Jason Mortzheim, GE Global Research*

**2:15 PM** -- *High Inlet Temperature Combustor for Direct Fired Supercritical Carbon Dioxide Power Cycles*  
*Jacob Delimont, Southwest Research Institute*

**3:00 PM** -- *Development of Modular, Low-Cost, High-Temperature Recuperators for the sCO<sub>2</sub> Power Cycle*  
*Marc Portnoff, Thar Energy, LLC*

### **3:45 PM -- COFFEE BREAK -- Latham A&B Foyer**

**4:15 PM** -- *Investigation of Autoignition and Combustion Stability of High Pressure Supercritical Carbon Dioxide Oxy-Combustion*  
*Wenting Sun, Georgia Institute of Technology*

**5:00 PM** -- *Chemical Kinetic Modeling Development and Validation Experiments for Direct Fired Supercritical Carbon Dioxide Combustor*  
*Subith Vasu, University of Central Florida*

**5:45 PM** -- *An Advanced Gas Foil Bearing Using sCO<sub>2</sub> as the Working Fluid*  
*Peter Chapman, Jr., Mechanical Solution, Inc.*

### **Materials (Track 3) -- Cascades Room**

**Moderator:** *Rin Burke, U.S. Department of Energy, National Energy Technology Laboratory*

**8:45 AM** -- *Abradable Sealing Materials for Emerging IGCC-Based Turbine Systems*  
*Daniel Mumm, University of California at Irvine*

# DETAILED PROGRAM

## WEDNESDAY, NOVEMBER 2

**9:30 AM** -- *Materials Issues for Advanced Supercritical CO<sub>2</sub> Cycles and High Efficiency Gas Turbines*  
Bruce Pint, ORNL

**10:15 AM** -- **COFFEE BREAK -- Latham A&B Foyer**

**10:45 AM** -- *Rapid Manufacturing Method for High-Temperature Turbine Components*  
John Paulus, Mikro Systems

**11:30 AM** -- *Ultra-High-Temperature Thermal Barrier Coatings*  
Eric Jordan, University of Connecticut and Solution Spray Technologies, LLC

**12:15 PM** -- **LUNCH -- Latham A&B**

**1:30 PM** -- *Durable High-Temperature Coatings for Utility Scale Gas Turbine Hot Gas Path Components and High Temperature Unique Low Thermal Conductivity Thermal Barrier Coating (TBC) Architectures*  
Amarendra Rai, UES, Inc.  
Douglas Wolfe, Pennsylvania State University

**2:15 PM** -- *Exploration of High Entropy Alloys for Turbine Applications*  
James Saal, QuesTek Innovations, LLC

**3:00 PM** -- *Advanced Bond Coats for Thermal Barrier Coating Systems Based on High Entropy Alloys*  
Derek Hass, Direct Vapor Technologies

**7:00 PM** -- **DINNER/DINNER SPEAKER -- Latham A&B**  
Tom Dingus, Director of Virginia Tech Transportation Institute

## THURSDAY, NOVEMBER 3

### REGISTRATION / CONTINENTAL BREAKFAST

**8:00 AM** -- Latham Foyer

### GENERAL SESSION -- Latham A&B

**8:45 AM** -- *UTSR Fellowship Program*  
Bill Day, KeyLogic

**9:00 AM** -- *The Future of UTSR in 2017*  
Richard Dennis, Advanced Turbines Technology Manager, U.S. Department of Energy,  
National Energy Technology Laboratory

**11:00 AM** -- *Open Discussions, Workshop Summary, Closing Comments, and Wrap-Up*  
Richard Dennis, Advanced Turbines Technology Manager, U.S. Department of Energy,  
National Energy Technology Laboratory

**11:30 AM** -- Adjourn



# KEYNOTE SPEAKERS

## RICHARD DENNIS

Mr. Richard Dennis is currently the Technology Manager for Advanced Turbines and Supercritical Carbon Dioxide Power Cycle Programs at the U.S. Department of Energy's National Energy Technology Laboratory (NETL). These programs are multi-million dollar per annum R&D activities managed for the US. DOE Office of Fossil Energy. The programs support university, industry and U.S. national laboratory research, development and demonstration projects. Rich has a BS and MS in Mechanical Engineering from West Virginia University. From 1983 to 1992 Mr. Dennis worked in the on-site research group of NETL where he conducted research related to pressurized fluidized bed combustion, gasification and gas stream particulate cleanup for advanced coal based power generation. From 1993 to 2000 Mr. Dennis managed contracted research for the DOE Office of Fossil Energy in advanced fossil fuel power generation including coal combustion, gasification, fuel cells, and gas turbines. In 2002 Richard was selected as the Turbine Technology Manager. In 2014 – 15 Dennis served as the technology manager for the DOE FE Advanced Combustion Systems technology area. Currently Richard is serving as the Technology Manager for Advanced Turbines and Supercritical Carbon Dioxide Power Cycles programs at NETL.

## TOM DINGUS

Dr. Thomas A. Dingus is director of the Virginia Tech Transportation Institute (VTTI), is an endowed professor in the Department of Biomedical Engineering and Mechanics at Virginia Tech, and is the president of VTT, LLC. He is center director of the U.S. Department of Transportation Tier 1 Connected Vehicle/Infrastructure University Transportation Center (CVI-UTC), which is a consortium of Virginia Tech/VTTI, the University of Virginia, and Morgan State University.

Since 1996, Dr. Dingus has managed the operations and research at VTTI. This multidisciplinary organization annually conducts more than \$36 million in sponsored program research expenditures. Prior to joining Virginia Tech, Dr. Dingus was founding director of the National Center for Transportation Technology at the University of Idaho and was an associate director of the Center for Computer-Aided Design at the University of Iowa.

Since 1984, Dr. Dingus has conducted transportation safety and human factors research related to driver distraction and attention, the safety and usability of advanced in-vehicle devices, crash avoidance countermeasures, and truck driver fatigue. He has pioneered studies of naturalistic driving, which involve instrumenting cars, trucks, and motorcycles with unobtrusive video cameras and sophisticated instrumentation (e.g., radar) designed to assess crash and near-crash causation and to test a variety of crash countermeasures. VTTI is currently leading such studies worldwide with more than 4,000 equipped vehicles deployed to date.

Dr. Dingus was named a White House Champion of Change and was selected for his exemplary leadership in developing or implementing transportation technology solutions. Dr. Dingus is a Fellow of the Human Factors and Ergonomics Society (HFES), from which he has received several awards, including the A.R. Lauer Award for outstanding contributions to the field of safety. He has had the honor of testifying before U.S. Congressional subcommittees (four times), the National Transportation Safety Board, and the National Council of State Legislatures about issues of driver distraction and attention. Dr. Dingus is a member of the boards of directors of the Association for Unmanned Vehicle Systems International and the Intelligent Transportation Society of America. He was recently elected to serve on Virginia Governor's Unmanned Systems Commission.

Dr. Dingus has more than 220 technical publications and has managed approximately \$300 million in research funding to date (\$130 million as principal investigator). Notable projects for which Dr. Dingus has served as a principal investigator or program manager include the 100-Car Study sponsored by the National Highway Traffic Safety Administration (NHTSA), the Heavy Truck Drowsy Driver Warning System sponsored by NHTSA, and the Second Strategic Highway Research Program (SHRP 2) Naturalistic Driving Study (NDS) sponsored by the National Academy of Sciences.



# KEYNOTE SPEAKERS

## MADHAV MARATHE

Madhav Marathe is the Director of the Network Dynamics and Simulation Science Laboratory at the Biocomplexity Institute of Virginia Tech and Professor of Computer Science at Virginia Tech. Before coming to Virginia Tech, he was a Team Leader in the Computer and Computational Sciences division at the Los Alamos National Laboratory where he led the basic research programs in foundations of computing and high performance simulation science for analyzing extremely large socio-technical and critical infrastructure systems. He has published more than 250 research articles in peer reviewed journals, conference proceedings, and books, and has over ten years of experience in project leadership and technology development, specializing in high performance computing algorithms and software environments for simulating and analyzing socio-technical network science. He is a Fellow of the IEEE, ACM and AAAS.

## THERESA MAYER

Theresa S. Mayer is the Vice President for Research and Innovation at Virginia Tech. She started her position in January 2016. She is also a Professor of Electrical and Computer Engineering in the College of Engineering. Prior to coming to VT, Theresa S. Mayer was a Distinguished Professor of Electrical Engineering and the Associate Dean for Research and Innovation in the College of Engineering at Penn State University, University Park. She received the B.S. degree in Electrical Engineering from Virginia Tech in 1988, and the Ph.D. degree in Electrical Engineering from Purdue University in 1994, where she was a Kodak Fellow. Prior to her current position, she served as the Associate Director of the Materials Research Institute, where she was the Site Director of the NSF National Nanotechnology Infrastructure Network and the Director of the Nanofabrication Laboratory. Her research is in hierarchical nanomanufacturing and its application in electronic and photonic microsystems with new functionalities. She has several hundred refereed technical publications, invited tutorials and presentations, and holds eight patents. Two companies have licensed technologies for commercialization.

Her research has been supported by agencies including the National Science Foundation, Department of Defense, National Institutes of Health, Department of Energy, and industry. She has programs in several multidisciplinary research centers, including the NSF Materials Research Science and Engineering Center (MRSEC) Center for Nanoscale Science, the STARnet Center for Low Energy Systems Technology, and the NSF Nanoscale Engineering Research Center (N-ERC) Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST).

Dr. Mayer has been active in professional societies, serving as the Technical Program Chair and General Chair of the IEEE Device Research Conference in 2005 and 2006, and the elected Vice-Chair and Program Chair of the Gordon Research Conference on Nanostructure Fabrication in 2004 and 2006. She is a member of the IEEE Electron Device Society Education Award Committee and the IEEE International Electron Devices Meeting Program Committee. She served as an executive committee member for the Electronic Materials and Photonics Division of the American Vacuum Society, the treasurer for the Electronic Materials Conference, and a symposium organizer for the Materials Research Society. Throughout her career, she has been active in engaging K-12 girls, undergraduate and graduate women in science and technology.

## GREGORY STROUSE

Gregory F. Strouse is the Associate Director for Measurement Services of the Physical Measurement Laboratory (PML) at the National Institute of Standards and Technology (NIST), and is a member of the board responsible for assessments of the NIST Quality System. Since joining NIST in 1988, he has become a leading expert in temperature measurement and the realization and dissemination of the International Temperature Scale of 1990 (ITS 90). He has designed and built up several new world-class facilities including laboratories for the calibration of standard platinum resistance thermometers, thermocouples and industrial thermometers, and he is a NVLAP technical and lead assessor. His current research interests include Quantum SI, NIST-on-a-Chip embedded sensors, cold-chain management for vaccines, dynamic pressure sensors and standards, Johnson noise thermometry, acoustic gas thermometry, realization of the Boltzmann constant, photonic pressure standards and sensors, and development of alternative thermometers.

**\*\*Note: Dr. Strouse is also a speaker on the Advanced Diagnostics for Modern Gas Turbine Engines Panel**

# PANEL SPEAKERS

## JASON DEES

Jason Dees is currently the manager of the Gas Turbine Heat Transfer Labs at GE Global Research, where he has worked since 2010. This team consists of approximately 20 researchers and is responsible for developing new turbine hot gas path thermal management technologies, including component cooling schemes, computational methodologies, and advanced thermal diagnostic techniques. Jason holds a BS in Mechanical Engineering from Louisiana Tech University and MS and PhD degrees from the University of Texas at Austin.

## SRINATH EKKAD

Professor Srinath Ekkad is currently the Associate Vice President for Research Programs at Virginia Tech. He also holds the Rolls-Royce Commonwealth Professorship in Aerospace Propulsion Systems in the College of Engineering and is a tenured Full Professor of Mechanical Engineering. He also serves as Director of the newly established University Technology Center for Rolls-Royce in Advanced System Diagnostics. In his academic career, he has worked on several research projects with a funding total over \$10 Million since 1998. His research focuses primarily on thermal management, energy concepts, propulsion, advanced diagnostics funded by NSF, DOE, Rolls-Royce, Siemens, GE, Solar Turbines, Honeywell, Elliot Turbo, Toyota, among others. He has supervised and supervising 33 MS and 19 PhD, 6 Postdoctoral Researchers and hosted 3 visiting scholars. He has also published over 200 technical papers (including 80 journal papers, 4 articles in books, and 130 conference papers) and one book (gas turbine heat transfer and cooling technology, 2nd edition). Srinath is an ASME Fellow and has received several awards for research and service both at the University level and at the National level (including the prestigious ASME Bergeles-Rhosenow Young Investigator Award in Heat Transfer) . He is very involved with ASME and IGTI where he organizes conferences and sessions. He also serves as associate editor for three journals. He has very good knowledge of university administrative procedures having served on committees at all levels of the University. As Associate VP for Research, he initiated cooperation between Office of Research and University Development for combined efforts to approach corporate relations to ensure more success in engaging with industry. He works with potential industry partners and provides a comprehensive strategy for engagement with Virginia Tech to the Industrial entity. This includes independent research projects, gifts, donation of equipment, scholarships, etc. He is also engaging faculty directly to provide them tools and advice to engage with industry. He has also been active in encouraging faculty and students to work on entrepreneurial activities across campus to develop university driven start-up companies.

## STEPHEN HEISTER

Stephen Heister is the Raisbeck Distinguished Professor in the Departments of Aeronautics and Astronautics and Mechanical Engineering at Purdue University. Professor Heister earned a B.S.E. and M.S.E. degrees in Aerospace Engineering from the University of Michigan in 1981 and 1983 respectively. He received his Ph.D. in Aerospace Engineering from UCLA in 1988. He has work experience at Lockheed California Company and The Aerospace Corporation where he spent the bulk of the 1980's. Prof. Heister has published extensively in the areas of chemical rocket and airbreathing combustion, atomization and fuel/propellant injection, injection dynamics, and system-level studies of aerospace vehicle concepts (including detonation-based propulsion).

From 2011-2016, Dr. Heister served as Director of the Maurice J. Zucrow Labs, a seven building complex involving 15 faculty and 90 graduate students with annual research expenditures of exceeding \$10M. Dr. Heister has received numerous honors and awards including: AIAA Fellow, Purdue University Faculty Scholar, 1998 - 2003, and five time winner of the E. F. Bruhn Teaching Award for the School of Aeronautics and Astronautics. In 2014, he was inducted into Purdue's Book of Great Teachers.

# PANEL SPEAKERS

## ATUL KOHLI

Dr. Atul Kohli is currently a Fellow of Heat Transfer, Analytical Methods in the aero-thermal discipline. In his 19 years at Pratt & Whitney, Atul has held positions of increasing responsibility within Turbine Aerodynamics, Multi Disciplinary Optimization, Turbine Durability, and Air Systems Design Integration disciplines. As Fellow, he leads the development/proficiency improvement of practitioners and the incorporation of state-of-art analytical methods for prediction of heat transfer into the design process.

Atul has a BS in Mechanical Engineering from the Indian Institute of Technology, a Masters and PhD in Mechanical Engineering from the University of Texas at Austin. As the technical focal point for the Pratt & Whitney Center of Excellence at Penn State University, Atul works closely with students and faculty on various research projects. He has over 30 refereed conference and journal publications and 15 issued patents with over 30 pending. Atul is active in the ASME heat transfer committee and was elected an ASME fellow in 2009.

## PETE LOFTUS

Pete has spent his 36-year career in Instrumentation and Measurement at Rolls-Royce.

His first challenges were concerned with the measurements associated with Jet engine testing. He progressed into managing this activity, ultimately running a department of 50 people working in this area before broadening his accountabilities.

He is currently Head of Measurement Engineering with accountability for ensuring the creation, maintenance and improvement of all forms of measurement capability for the company world-wide.

He holds a Bachelor's Degree in Applied Physics and a Masters in Gas Turbine Engineering.

He is President of the European Virtual Institute for Gas Turbine Engineering; and active in the ASME International Gas Turbine Institute, The Institution of Engineering and Technology, and NCSLI.

He is married with grown up children and in his spare time is a scout leader and Engineering Ambassador.

## SUSAN MALEY

Susan Maley has spent most of her career developing and applying sensor and control technologies. Prior to joining EPRI in January, 2015, she spent 14 years with the U.S. Department of Energy, leading programs in the Crosscutting Research Program for DOE's Office of Fossil Energy National Energy Technology Laboratory. Those programs included advanced sensors and controls, the advanced energy concepts area, the high-performance materials program, computational sciences, and the water management R&D program. In her current role, Susan is leading the Instrumentation, Control and Automation Program for EPRI's Generation Sector and also is the leader of EPRI's Intelligent Generation Initiative (I4Gen) and is part of the team working on the Research Imperative (RI) in Sensors and Analytics. She has bachelors and masters degrees in chemical engineering.

## DOUGLAS RAWLINS

Dr. Rawlins is currently the Manager of Advanced Technology at Solar Turbines, a position he has held for the past 8 years. He is responsible for coordinating the research and development necessary to achieve TRL 6 for technologies that will be implemented in Solar's gas turbines in the next 5-10 years. Dr. Rawlins has been with Solar Turbines for the past 28 years, after graduating from Brigham Young University with a PhD in Combustion Engineering.



# PANEL SPEAKERS

## ROBERT ROMANOSKY

Dr. Robert Romanosky is currently the Acting Crosscutting Technology Manager in the Office of Strategic Planning. Bob received both his M.S. and Ph.D. from West Virginia University in analytical chemistry/instrumentation. He has been with the U.S. Department of Energy, National Energy Technology Laboratory, since 1978, spending 18 years working in areas involved in all aspects of both laboratory and process research dealing with advanced instrumentation and process analysis on power systems. For the next 17 years, Dr. Romanosky was the Technology Manager for Power Systems Advanced Crosscutting Research. Dr. Romanosky then served as the Deputy Director, Office of Coal and Power R&D, from 2013 to 2015, before returning to the position of Crosscutting Technology Manager in the Office of Strategic Planning. This technology area encompasses research activities in Advanced Materials, Plant Optimization Technologies, Advanced Systems Modeling, Coal Utilization Sciences, and University Training and Research. Plant Optimization Technologies supports the development of novel sensors and control systems critical to the implementation and optimization of advanced fossil fuel-based power generation systems, including new classes of sensors capable of monitoring key parameters (temperature, pressure, and gases) while operating in harsh environments.

## KAREN THOLE

Professor Karen A. Thole is the head of the Department of Mechanical and Nuclear Engineering at The Pennsylvania State University. Professor Thole's expertise is in convective heat transfer. She founded the Steady Thermal Aero Research Turbine Laboratory, which is a center of excellence for gas turbine heat transfer for Pratt & Whitney. She has led over \$30M in research grants and has published over 200 refereed papers. She has advised over 65 dissertations and theses. She has been recognized by the U.S. White House as a Champion of Change for STEM and by ASME's George Westinghouse Gold Medal and Edwin F. Church Medal. She holds degrees from the University of Illinois and the University of Texas at Austin.

## PAUL ZOMBO

Paul Zombo has been working in the fields of Metallurgy, Failure Analysis and Non-destructive Examination for thirty-two years since earning a degree in Metallurgical Engineering. His areas of involvement include: diagnostics, welding, manufacturing, repair, and materials development used in power generation, aerospace, and heavy industry. Paul has 38 patents & 29 publications in the fields of NDE, in-situ inspection, welding and metallurgy. Paul was honored as "Siemens Inventor of the Year 2009" for outstanding innovation.

# POSTER PRESENTATIONS

*Gas Turbine Hot Gas Path Hardware Concept Design Using Additive Techniques*  
Christopher Gimmler, University of Central Florida

*Correlating Thermal Barrier Coating Microstructure Between Engine Run Combustion Hardware and Furnace Cycle Testing*  
Kara Phillips Bridges, University of California at Irvine

*Hot Gas Ingress Modeling*  
Robert LaFaso, University of Wyoming

*Advanced Gas Foil Bearing Design for Supercritical CO<sub>2</sub> Power Cycles*  
Peter Chapman, Jr., Mechanical Solutions, Inc.

*Supercritical CO<sub>2</sub> Turbomachinery Design System*  
Mark Anderson and Dan Hinch, Concepts NREC

*Superalloy MMC Components for Advanced Turbine Systems*  
Dean Baker and Asit Biswas, Advanced Powder Solutions, Inc.

*Effects of Turbulence on Harmonically Excited Flames*  
Tim Lieuwen, Georgia Institute of Technology

*sCO<sub>2</sub> Brayton Power Cycle Heat Exchanger Test Facility*  
Marc Portnoff, Thar Energy, LLC

*Nanoscale Metal Oxide Coatings for Corrosion Protection of Component Materials Used in Supercritical CO<sub>2</sub> Environments*  
Christopher Oldham, NC State University

*Chemical Pathways for Turbulent CH<sub>4</sub>-Air Flames*  
Debolina Dasgupta, Georgia Institute of Technology

*Sensitivity of Extinction & Re-Ignition Predications to Finite-Rate Chemical Models in a Temporally Evolving Turbulent Non-Premixed Syngas Flame*  
Wenting Sun, Georgia Institute of Technology

*Constitutive Response of IN 718*  
Thomas Siegmund, Purdue University

*Computationally-Designed Alloys for Turbine Applications*  
James Saal, QuesTek Innovations LLC

*Deposition Research at OSU*  
Ryan Lundgreen, The Ohio State University





# POSTER PRESENTATIONS

*Flow and Heat Transfer in a Smooth U-Duct with Trapezoidal Cross Section*  
Kenny Hu, Purdue University

*Effects of Wake Shedding on Flow and Heat Transfer in an Internal Cooling Passage with a Staggered Array of Pin Fins*  
Chien-Shing Lee, Purdue University

*Measurements of Turbulent Flame Speeds for Syngas Mixture*  
Henderson Johnson II and Tim Lieuwen, Georgia Institute of Technology

*Experimental Investigation of the Onset of Sand Deposits on Hastelloy-X Above 1000 °C*  
Andrew Boulanger, Virginia Tech

*Matlab Implementation of a First-Order Compressor Sizing Tool*  
Iggy Matheson, Brigham Young University

*Advanced Internal Cooling Concepts: Rotating Conditions*  
Prashant Singh, Virginia Tech

*Advanced Internal Cooling Concepts: Stationary Conditions*  
Prashant Singh, Virginia Tech



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