ASME INTERNATIONAL GAS TURBINE INSTITUTE

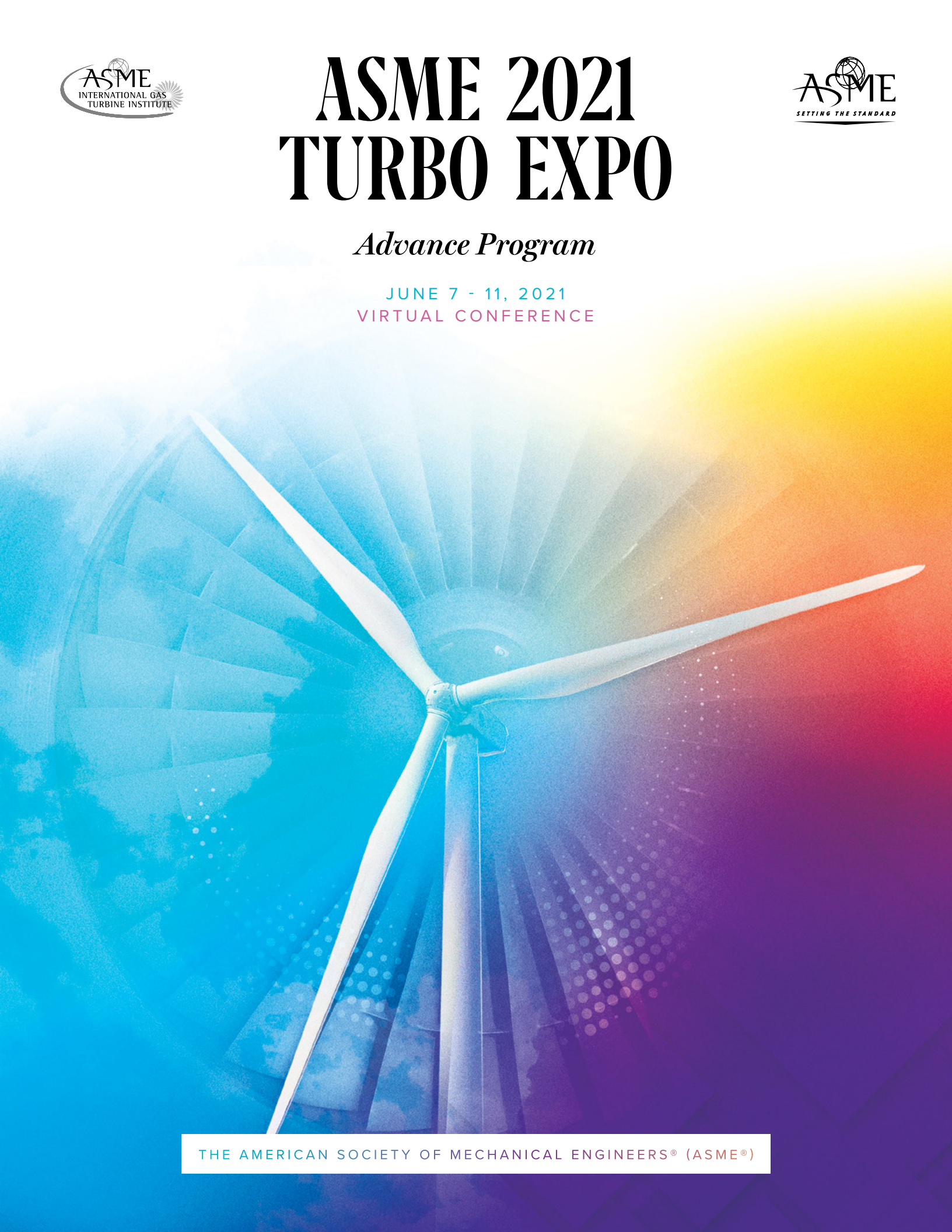
ASME 2021 TURBO EXPO

ASME SETTING THE STANDARD

Advance Program

JUNE 7 - 11, 2021

VIRTUAL CONFERENCE



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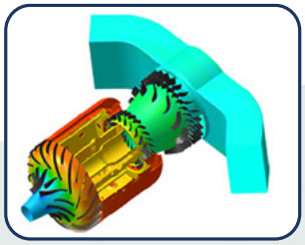
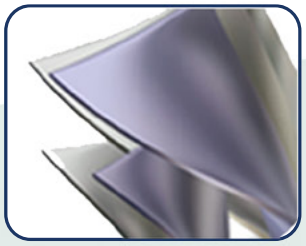
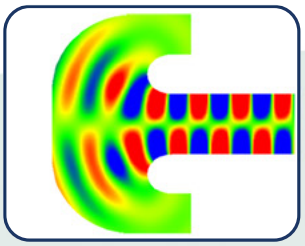


Full engine CFD simulation with NLH



Robust Design Optimization with UncertaintyQuantification



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High temperature non-contact clearance measurement systems for gas turbine clearance monitoring of blades and shafts.

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Solar Turbines provides gas turbine packages and services for oil and gas and power generation industries.

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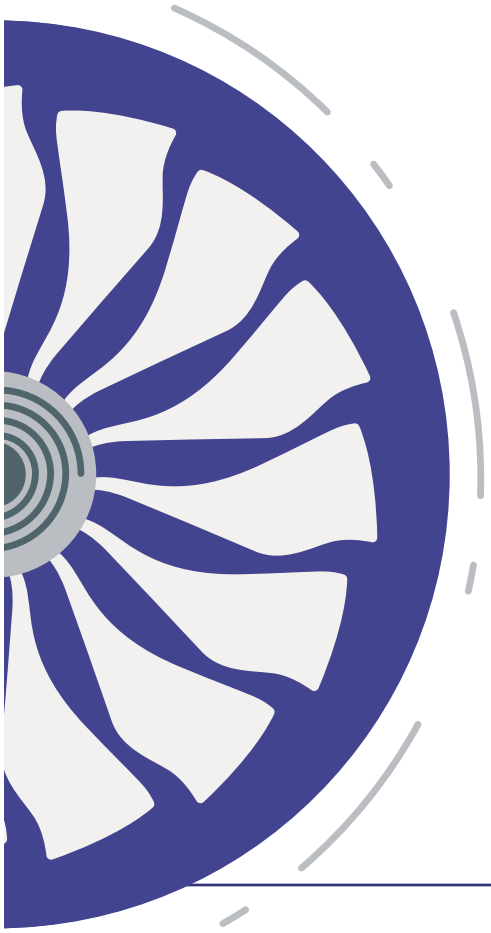
www.machinery.swri.org

Southwest Research Institute® (SwRI®) performs turbomachinery R&D for power, compression, and propulsion applications.



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ASME TURBO EXPO 2021

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ASME Gas Turbine Segment

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event.asme.org/Turbo-Expo

Join us online for the 2021 ASME Turbo Expo Technical Conference and Exhibition.

ATE Antriebstechnik und Entwicklungs GmbH & Co. KG

Brandenburger Str. 10, 88299 Leutkirch, Germany

www.ate-system.de/en

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Calspan Systems Corporation is an industry leader in designing and manufacturing turbomachinery test rigs.

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Exhibitors (Continued)

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NASA's Vision: We reach for new heights and reveal the unknown for the benefit of humankind.

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626 Cochrans Mill Road, Pittsburgh, PA, 15236 USA

www.netl.doe.gov

The National Energy Technology Laboratory (NETL) is a U.S. Department of Energy (DOE) national laboratory that produces technological solutions to America's energy challenges.

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Neural Concept is an AI solution for real time CAE simulations and performance maps in turbomachinery.

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The Turbomachinery & Pump Symposia is a vital industry event offering a forum for the exchange of ideas between rotating equipment engineers and technicians worldwide.

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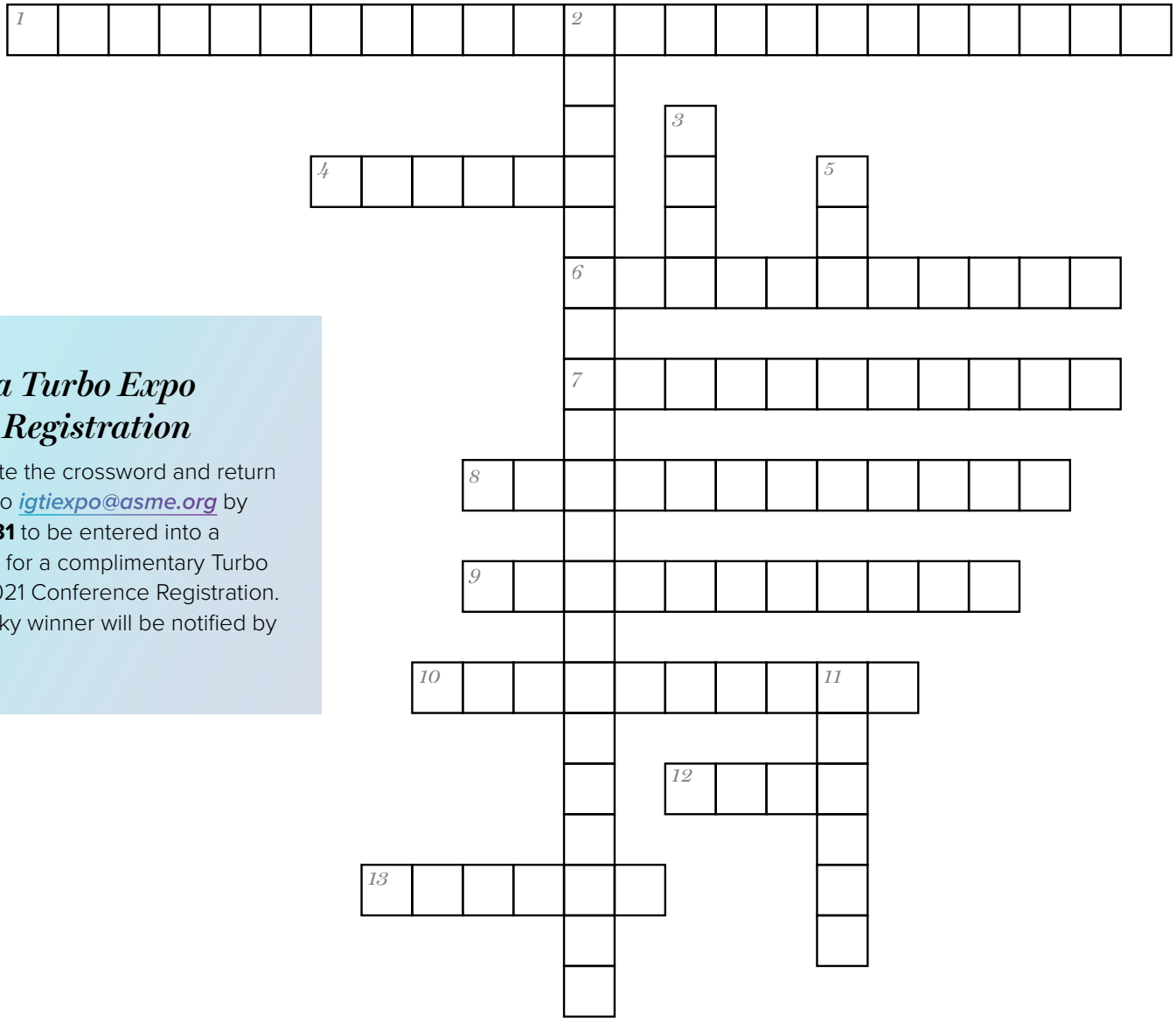
For a complete listing, visit event.asme.org/Turbo-Expo/Sponsor-Exhibit.

TURBO EXPO CROSSWORD



Win a Turbo Expo 2021 Registration

Complete the crossword and return a copy to *igtiexpo@asme.org* by **March 31** to be entered into a drawing for a complimentary Turbo Expo 2021 Conference Registration. One lucky winner will be notified by April 1.

DOWN

2. Chair of the IGTI Executive Committee

3. Number of Students on the Student Advisory Committee

5. How many times has Turbo Expo been held in Asia?

11. Location for Turbo Expo 2024

ACROSS

1. Publishes archival-quality, peer-reviewed technical papers that advance the state-of-the-art of turbomachinery technology related to gas turbine engines.

4. Silver Sponsor.

6. City that hosted Turbo Expo in 1986.

7. Gas Turbine Segment Chair

8. Journal of Engineering for Gas Turbines and Power Editor

9. In what Country was the first international Turbo Expo event held in 1966?

10. Turbo Expo 2021 Conference Chair

12. IGTI Newsletter

13. The Virtual Event is available for XX days after the end of the show.

TURBO EXPO 2021 VIRTUAL CONFERENCE

THE MUST-ATTEND EVENT FOR TURBOMACHINERY PROFESSIONALS

Register online at www.turboexpo.org

Over 1,500 attendees expected!

Over 700 papers expected to be presentated plus:

- A Student Poster Competition
- A Scholar Lecture
- Featured Lectures
  - Aircraft Engine Technology Award Lecture
  - Industrial Gas Turbine Technology Award Lecture

The Virtual Conference will have improved:

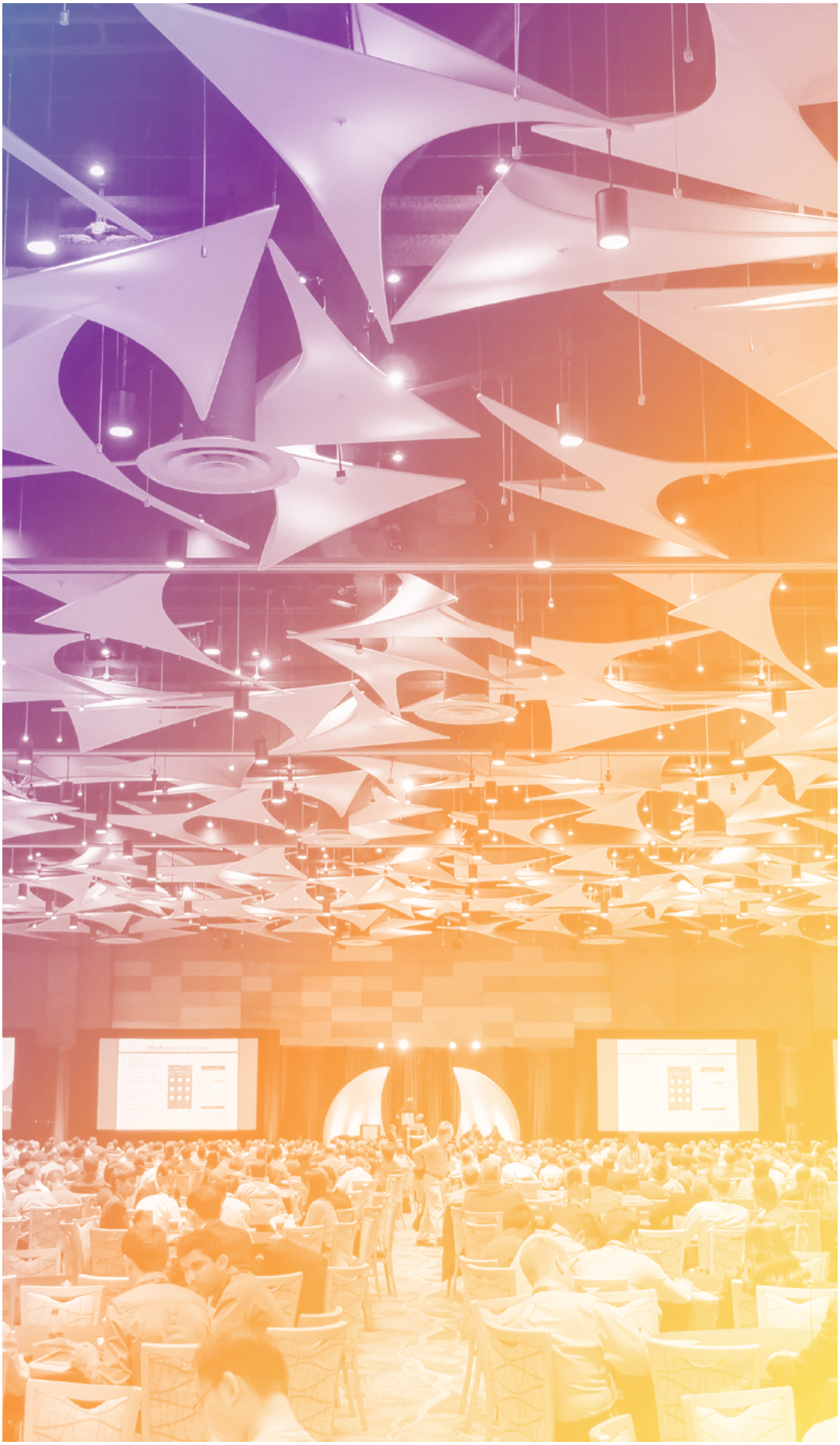
- Networking capabilities
- More opportunities in the program to connect with your community
- Q&A after each presentation

Click here to watch the Virtual Conference Video

2020 Virtual Event Quick Stats

PAPER SESSIONS 289	TUTORIALS 24	TECHNICAL PAPERS 965	ATTENDEES 1,588
STUDENTS 464	EXHIBITING COMPANIES 21	SPONSORS 6	STUDENT POSTERS 32

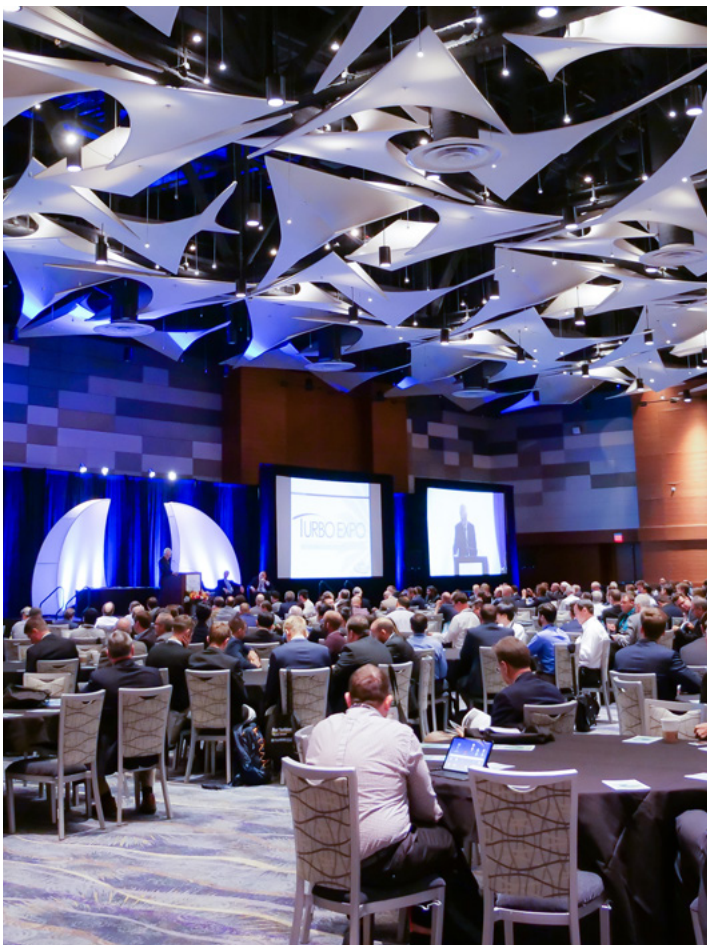
CONFERENCE THEME & AWARDS INFORMATION



Virtual Conference Theme

SUSTAINABLE ENERGY—ACCELERATING THE TRANSITION BY ADVANCING TURBINE TECHNOLOGY

Nations of the world are seeking a transition to a sustainable carbon neutral existence by 2050; a society driven speed unparalleled in modern times. The ability to quickly apply and adapt turbine technology to carbon neutral fuels, hybrid power systems and alternate heat sources will help to accelerate the transition to sustainable energy systems. The transition will require a close collaboration between power generation and propulsion industries, the research communities and regulators but also other industries outside the traditional turbomachinery area in order to create a feasible roadmap for technology development.



To make this vital transition, the community will need further development of new digital design tools, advanced manufacturing, integrated sensor technology, machine learning with artificial intelligence, pre & post combustion carbon capture and advanced thermodynamic systems. Additional focus should be put onto the infrastructure requirements for alternative fuels and the end-to-end ecosystem of power and propulsion generation.

Organizers of Turbo Expo 2021 invite you to explore and share topics relevant to advance turbine technology as the industry works to provide solutions for sustainable energy. A series of panel discussions will be organized with selected experts to discuss technologies needed to achieve sustainable energy solutions.

Plenary Sessions

The plenary sessions will be held 8:00 – 9:00 am Eastern Time. ASME IGTI awardees will be recognized following each plenary session from 9:00 – 9:30 am. Make plans to support your peers!

TUESDAY, JUNE 8, 2021 | 8:00 – 9:00 AM

Opening up the Design Space to Afford Efficient Gas Turbines Using H_2 and Biofuels

WEDNESDAY, JUNE 9, 2021 | 8:00 – 9:00 AM

Opening up the Design Space Through Computations and Machine Learning

THURSDAY, JUNE 10, 2021 | 8:00 – 9:00 AM

Engineering in 2030 – How Must Our Educational Programs Change to Better Equip the Needed Workforce

AWARDS

The ASME R. Tom Sawyer Award

AUGUST 30, 2021

Your nomination package should be received at the ASME Office no later than the above date to be considered.

Email completed nomination package to:

igtiawards@asme.org

The **R. Tom Sawyer Award** is bestowed on an individual who has made important contributions to advance the purpose of the Gas Turbine Industry and to the International Gas Turbine Institute over a substantial period of time. The contribution may be in any area of institute activity but must be marked by sustained forthright efforts. The award was established in 1972 to honor R. Tom Sawyer who, for over four decades, toiled zealously to advance gas turbine technology in all of its aspects and includes a US $1000 honorarium and a plaque presented during ASME Turbo Expo.

The nomination must be complete and accompanied by three to five Letters of Recommendation from individuals who are well acquainted with the nominees' qualifications. Candidate nominations remain in effect for three years and are automatically carried over. The completed reference form from a minimum of 3 people will need to be sent in with the nomination package. It is up to the "Nominator" to submit all required information.

Congratulations to the 2020 ASME R. Tom Sawyer Award winner Sunao Aoki, Executive Corporate Adviser, Mitsubishi Heavy Industries, Inc. (Retired 2019).

The ASME Gas Turbine Award

CLICK HERE FOR MORE INFORMATION

The **Gas Turbine Award** is given in recognition of an outstanding individual--or multiple--author contribution to the literature of combustion gas turbines or gas turbines thermally combined with nuclear or steam power plants. The paper may be devoted to design aspects or overall gas turbines or individual components and/or systems such as compressors, combustion systems, turbines, controls and accessories, bearings, regenerators, inlet air filters, silencers, etc. It may cover topics specifically related to gas turbines such as high temperature materials or fuel considerations, including erosion and corrosion complications. It can also be devoted to application or operational aspects of gas turbines for aircraft propulsion and ground power units, or automotive, electric utility, gas pipeline pumping, locomotive, marine, oil field pumping, petrochemical, space power, steel, and similar uses. This award was established in 1963 and includes a US $1000 honorarium and a plaque presented during ASME Turbo Expo.

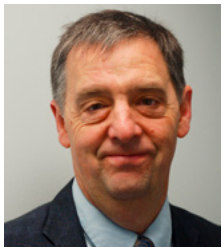
Congratulations to the 2018 ASME Gas Turbine Award winners Bogdan Cernat, Marek Paty, Cis De Maesschalck, Sergio Lavagnoli.

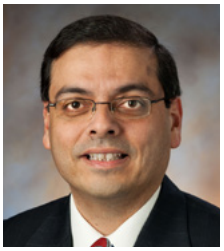
& SCHOLARSHIPS

AWARDS

ASME Dedicated Service Award

The **ASME Dedicated Service Award** honors unusual dedicated voluntary service to the Society marked by outstanding performance, demonstrated effective leadership, prolonged and committed service, devotion, enthusiasm and faithfulness.





Congratulations to the 2020 award winners Michael Klassen, Combustion Science & Engineering, Inc. & Atul Kohli, Pratt & Whitney.

The ASME IGTI Aircraft Engine Technology Award

OCTOBER 15, 2021

Nominating and supporting letters for the Aircraft Engine Technology Award should be sent by the above date to:

igtiawards@asme.org

The **Aircraft Engine Award** recognizes sustained personal creative contributions to aircraft gas turbine engine technology. Eligible areas of accomplishment are aircraft engine design, and/or research and development performed in an industrial, academic or research laboratory environment in one or more of the following fields:

- Aircraft Engine Propulsion
- Airframe-Propulsion Integration
- Combustion & Fuels
- Controls
- Diagnostics
- Heat Transfer
- Manufacturing Materials & Metallurgy
- Operability
- Structures & Dynamics
- Turbomachinery

The Aircraft Engine Technology Award will include an optional opportunity to deliver a lecture or present an invited technical paper on the work for which the award is being bestowed, at ASME Turbo Expo. The recipient of the award will very desirably, but not necessarily, be a member of The American Society of Mechanical Engineers. The award will be made to a single individual.

Nominating letters should contain all information on the nominee's relevant qualifications. The Award Committee will not solicit or consider materials other than those described below. The selection committee will hold nominations active for a period of three years.

A minimum of two supporting letters from individuals, other than the nominator, must accompany the nominating letter. Supporting letters should reflect peer recognition of the nominee's breadth of experience with various aspects of industrial gas turbine technology.

Congratulations to the 2020 Aircraft Engine Technology Award winner Dr. Wing Ng, Chris Kraft Endowed Professor, College of Engineering at VaTech.

& SCHOLARSHIPS

AWARDS

The ASME IGTI Scholar Award

SEPTEMBER 1, 2021

Your nomination package should be received at the ASME Office no later than the above date to be considered.

Email completed nomination package to:

igtiawards@asme.org

Established in 1989, ASME IGTI gives the **ASME IGTI Scholar Award** biannually to a person with a significant depth of knowledge in some aspect of gas turbine technology, who writes and presents a learned and comprehensive paper to industry peers. The recipient may be from industry, government, education, or private professional practice and need not be an ASME member.

The 2023 Scholar Award nomination form may be found here: *community.asme.org/international_gas_turbine_institute_igti/m/mediagallery/8063/download.aspx*

Congratulations to the 2019 Scholar Award winner Dr. Kenneth Suder, Chief of Turbomachinery and Turboelectric Systems, NASA Glenn.

John P. Davis Award

Awarded annually by ASME IGTI in recognition of the technical paper that most significantly describes new or continuing gas turbine applications; identifies planning, installation, operating and/or maintenance problems and their solutions; and exemplifies candid exposure of real-world problems and solutions and is judged, therefore, to be of exceptional value to others supplying or using gas turbines and their support systems. The Award was established in 1985 and includes a US $1,000 honorarium (divided equally among recipients if awarded to a multiple-author paper) and is presented at ASME Turbo Expo.

Congratulations to the 2018 ASME Gas Turbine Award winners Dr. Sung Choi, Science & Technology Lead, Naval Air Systems Command and David Shifler, S&T Program Officer, Office of Naval Research.

& SCHOLARSHIPS

AWARDS

The ASME IGTI Industrial Gas Turbine Technology Award

OCTOBER 15, 2021

Nominating and supporting letters for the Industrial Gas Turbine Technology Award should be sent by the above date to:

igtiawards@asme.org

The **Industrial Gas Turbine Award** recognizes sustained personal creative scientific or technological contributions unique to electric power or mechanical drive industrial gas turbine technology. Eligible areas of accomplishment are gas turbine design, application, operations/maintenance, and research/development/deployment, performed in an industrial, academic or research laboratory environment in one or more of the following fields:

- Combustion, Fuels, & Emissions Abatement
- Controls
- Diagnostics
- Electric Power Plant Integration
- Fluid Dynamics & Thermal Sciences
- Operation, Maintenance, & Life Cycle Cost
- Manufacturing, Materials, & Metallurgy
- Structures & Dynamics
- Thermodynamic Cycles
- Turbomachinery

The Industrial Gas Turbine Technology Award will include an optional opportunity to deliver a lecture or present an invited technical paper on the work for which the award is being bestowed, at ASME Turbo Expo. The recipient of the award will very desirably, but not necessarily, be a member of The American Society of Mechanical Engineers. The award will be made to a single individual.

Nominating letters should contain all information on the nominee's relevant qualifications. The Award Committee will not solicit or consider materials other than those described below. The selection committee will hold nominations active for a period of three years.

A minimum of two supporting letters from individuals, other than the nominator, must accompany the nominating letter. Supporting letters should reflect peer recognition of the nominee's breadth of experience with various aspects of industrial gas turbine technology.

Congratulations to the 2020 Industrial Gas Turbine Technology Award winner Dr. Thomas Sattelmayer, Technical University of Munich.

& SCHOLARSHIPS

AWARDS

ASME IGTI Dilip R. Ballal Early Career Award

AUGUST 1, 2021

Nomination packets are due to ASME on or before the above date. Send complete nomination to:

igtiawards@asme.org

Early Career Awards are intended to honor individuals who have outstanding accomplishments during the beginning of their careers. Historically, there has been no such award to recognize early career engineers working in the area of turbomachinery.

An early career award is intended for those starting a professional career, which is typically after a relevant terminal degree: BS, MS, or PhD. A criterion of seven-years-from-degree will be used to define the nominee's eligibility. The nominee must receive the award prior to the completion of the seventh year beyond the terminal degree.

The recipient of the **Dilip Ballal Early Career Award** will be presented with the award at Turbo Expo. The award consists of a plaque, funds to support the travel and registration costs to Turbo Expo, free ASME membership registration for five years, and a US $2000 honorarium.

Nomination Requirements

The nomination package should include the following:

a. A paragraph (less than 50 words) from the nominator highlighting nominee's contributions
b. Nomination letter
c. Two supporting letters
d. Current resume of the nominee

Congratulations to the 2020 Dilip R. Ballal Early Career Award winner Dr. Reid Berdanier, Penn State University.

& SCHOLARSHIPS

AWARDS

Student Advisory Committee Travel Award

The SACTA deadline for nomination has passed. Winners will be notified in February.

The SAC is pleased to announce that 40 **Student Advisory Committee Travel Awards (SACTA)** have been made available for students in 2021, with priority given to students who both participate in the conference and actively contribute to the growth of the SAC. The award will consist of a **Complimentary Technical Conference Registration** to attend the 2021 Virtual Turbo-Expo in June. Applicants for these awards must be seeking a degree. Preference will be given to students who have previously worked and/or have applied to work as student liaison for Turbo-Expo 2021. The applicant must agree to participate in the SAC Annual Meeting and be willing to help the SAC leadership team review student posters. Communication with the SAC leadership team may be requested prior to, during, and following Turbo Expo.

Information can be found at: *event.asme.org/Turbo-Expo/Students/Student-Travel-Awards*

Congratulations to the 2020 Award Winners:

Dino Anthony Celli, *The Ohio State University*

Tânia Sofia Cação Ferreira, *Université catholique de Louvain/von Karman Institute for Fluid Dynamics*

Spencer Sperling, *The Ohio State University*

Avinash Ambadas Renuke, *University of Genoa, Italy*

Manas Madasseri Payyappalli, *Indian Institute of Technology Bombay*

Richard Alan Celestina, *The Ohio State University*

Elissavet Boufidi, *von Karman Institute/ Université Catholique de Louvain*

Mavroudis D. Kavvalos, *Malardalen University (MDH)*

Matthew Aaron Meier, *Purdue University*

Louis Edward Christensen, *The Ohio State University*

Alessandro Romei, *Politecnico di Milanp*

Brian, *Frederick Knisely, Pennsylvania State University*

Kedar Prasad Nawathe, *University of Minnesota - Twin Cities*

Rahul Kumar, *Indian Institute of Technology Madras*

Mohammed Ibrahim Kittur, *University of Malaya*

Kishore Ranganath, *Ramakrishnan, North Carolina State University*

Bernhard Stiehl, *University of Central Florida*

Shinjan Ghosh, *University of Central Florida*

Shuo Mao, *Virginia Tech*

Erik Matthew Ninnemann, *University of Central Florida*

2019 SACTA Winners

& SCHOLARSHIPS

AWARDS

Young Engineer Turbo Expo Participation Award

Nomination Deadline for ASME Turbo Expo 2021 was February 1.

Winners will be notified in March.

The ASME Gas Turbine Segment **Young Engineer Turbo Expo Participation Award (YETEP)** is intended for young engineers at companies, in government service, or engineering undergraduate or graduate students in the gas turbine or related fields to obtain travel funding to attend ASME Turbo Expo to present a paper which they have authored or co-authored. The purpose is to provide a way for more to participate in the annual Turbo Expo.

The nominee must have obtained an academic degree (Bachelor, Master, PhD, or equivalent degrees) in an engineering discipline related to turbomachinery within five years from the year of the Turbo Expo that the applicant wishes to attend. The research results the applicant wishes to present at the conference can have been obtained either while pursuing an academic degree, or afterwards (students, professionals or young academics are eligible).

For 2021, ASME IGTI will provide YETEP Award winners with:

- **One Complimentary ASME Turbo Expo Technical Conference Registration**

Congratulations to the 2020 Award Winners:

Mahmood Alqefl, *Praxair*
Maria Alessadandra Ancona, *University of Bologna*
James Braun, *Purdue University*
Elise Delhez, *University of Liege (Belgium) & Polytechnique Montreal (Canada)*
Scott Egbert, *University of Colorado Boulder*
Saarthak Gupta, *Indian Institute of Science*
Xiao He, *Imperial College London*
Shreyas Hedge, *Duke University*
Daniel Inman, *Purdue University/ USA Air Force*
Hardik Jani, *Texas A&M University*
Andressa Johnson, *University of Connecticut*
Hussain Kaizar, *Texas A&M University*
Zhihui Li, *Institute of Engineering Thermophysics, Chinese Academy of Sciences*
Marco Manfredi, *Politecnico di Milano*
Luca Mantelli, *Università degli Studi di Genova*
Izzet Sahin, *Texas A&M University*
Hari Shrestha, *Atlas Copco Comptec LLC*
Sanna Siddiqui, *Florida Polytechnic University*
Dung Tran, *Energy Recovery Inc*
Xing Yang, *Xi'an Jiaotong Universit*

For 2022 YETEP information, visit:
go.asme.org/IGTI

& SCHOLARSHIPS

AWARDS

ASME IGTI Student Scholarship Program

FEBRUARY 18, 2021
Undergraduate Applications

MARCH 4, 2021
Graduate Applications

Student application deadline for the 2021-2022 Academic School Year.

Scholarship winners will be notified by July 31, 2021.

ASME IGTI has a long and proud history of providing scholarships to students who show promise for their future profession in the turbomachinery field. The aim is to attract young talent to the profession and reward their commitment, favoring their upcoming enrollment and active participation. The scholarship is to be used for tuition, books and other University expenses. The check will be made out to the University on the student's behalf.

Eligibility of the Applicants

ASME Scholarships are awarded annually to eligible ASME Student Members. **You must be a current ASME student member in good standing** (for login to the ASME online scholarship application). Click here to *Join ASME* or to *Renew* your dues.

To be eligible, you must be a community college, college, or university student who is enrolled full-time in Mechanical Engineering (ME), Mechanical Engineering Technology (MET), or closely related engineering studies.

For your major to be considered closely related to a Mechanical Engineering major, you must be taking at least 25% of your credits each semester in courses from the Mechanical Engineering Department.

Congratulations to the 2020-2021 Award Winners:

Diego Alarcon Verlezza, *University of Georgia*
Alene Basmadjian, *University of Oklahoma Norman Campus*
Nathanael Chu, *University of Texas at Austin*
Erin Dubas, *University of Virginia-Main Campus*
Raphael Hatami , *University of Colorado Denver*
Adam Hernandez-Miranda, *University of Guanajuato*
Jake Johnson, *Boise State University*
Mohammad Kahn, *University of Southern California*
Dylan Konop, *Bradley University*
Scotty Lucas, *University of the Pacific*
Nicolas Maciel, *Northeastern University*
Benjamin Mathew, *LeTourneau University*
Damilola Ojedeji, *Louisiana State University - Baton Rouge*
Elyssa Penson, *Bucknell University*
Timothy Riordan, *Virginia Polytechnic Institute and State University*
Anna Stevenson, *University of Alabama*
V Sai Subhankar, *IIT Kharagpur*
Thomas Townsend, *University of Arkansas Main Campus*
Jarred Vasinko, *Penn State University Park*
Mario Alejandro Zuniga Servin, *ITESM, Monterrey Campus*

For complete information on the scholarship program and application process, visit:

asme.org/career-education/scholarships-and-grants/scholarship/asme-scholarships-how-to-apply

NOTE

When you complete the online application, you will be considered for all ASME scholarships for which you qualify, not just the ASME IGTI scholarship.

& SCHOLARSHIPS

TECHNICAL SESSIONS

The Technical Conference has a well-earned reputation as the premier forum on all aspects of gas turbine and related turbine technology. The 2021 Program features technical sessions, panel discussions, tutorials, user-focused sessions and more.

TECHNICAL SESSIONS

Aircraft Engine

Sessions within this track address issues of interest across a broad spectrum of aircraft engine technology subjects.

Presenters will cover a range of topics including:

- Modeling, Simulation and Validation
- Operability, Whole Engine Performance and Novel Concepts
- Combustion and Emissions
- Thermal Management Systems and Aero-Engine Oil Systems
- Controls, Diagnostics and Instrumentation
- Inlets, Ducts, and Boundary Layer Ingestion
- Systems Integration of Electrified and Hybrid Aircraft

Additionally, the following tutorial and panel sessions will be presented:

- Basics of Turboshaft Engine Cycle Design and Optimization
- Overview of Fatigue Life Modeling

Ceramics

Ceramic matrix composites offer great potential for hot section applications in aero gas turbines and land based power generation plant. Their inherent low density and high temperature capability offer weight savings in component designs and efficiency gains resulting from reduced cooling requirements. As a result of more efficient combustion characteristics, crucial reductions in greenhouse gas emissions may be achieved.

The technical challenges for this class of materials include material processing, characterization, analysis and design, and environmental protection coatings. Demonstrators and even service experience are now informing the academic and industrial communities of the engineering capabilities of CMCs. Leading research groups will present their latest R&D activities in the following areas:

- Mechanical Behavior
- Damage & Fracture Modelling
- Erosion Behavior
- Coatings

Coal, Biomass & Alternative Fuels

Sessions focus on high-interest topics in the area of alternative fuel systems for gas turbines, including Hydrogen fuel systems, steam turbines, and other turbomachinery technologies. Alternative and renewable fuels including gaseous and liquid hydrocarbon fuels, alcohols, and ethers; as well as pure hydrogen, or high hydrogen content fuels. Alternative liquid hydrocarbon fuels derived from coal or biomass feedstocks or other technologies. Technical, tutorial, and panel sessions will cover the fundamental physical and chemical properties of alternate and renewable fuels, important to their use in gas-turbine engines and other power systems, as well as their application in different power systems. Sessions will be of interest to researchers, technologists, computational methods involved in the generation and utilization of non-conventional fuels in gas-turbine-based energy systems, and for those wishing to start a new activity in this field.

- Hydrogen Fuel Delivery Systems
- Hydrogen and Hydrogen Content Fuels for Gas Turbine Applications
- Alternative Fuel Chemistry and Fundamentals
- Alternative Fuel Use in Gas-Turbine Engines
- Basics of Hydrogen and Alternative Fuels
- Liquid Fuel Atomization and Combustion
- Computational Methods for Hydrogen and other Alternate Fuels
- Basics of Combustion Computational Fluid Dynamics

TECHNICAL SESSIONS

Combustion, Fuels & Emissions

Aero and Industrial Gas Turbines with low specific fuel consumption and reduced CO_2 emissions require high combustor outlet temperatures with a continued emphasis on reducing emissions, without sacrificing operability or durability. In addition, combustion systems are increasingly expected to operate with synthetic gaseous fuels or alternative liquid fuels. The Combustion, Fuels & Emissions sessions will highlight new technology and design approaches, using both experimental and computational techniques, employed to achieve improved combustor performance including ultra-low pollutant emissions and enhanced operability such as turndown and transient response. Broad trends for the 2020 conference include a continued focus on combustion dynamics for lean, staged combustion systems, significant innovation in the development of combustion system such as dry low NO_x or novel rotary detonation, maturation of large eddy simulation analyses, as well as continued research of fundamental and applied topics in atomization, mixing, ignition, auto ignition, blowout and chemical kinetics.

Technical sessions include:

- Ignition & Auto Ignition
- Atomization & Sprays
- Fundamental Combustion
- Novel Combustion Concepts
- Flashback & Blowout
- Pollutant Emissions Formation & Control: Combustor Performance
- Combustor Design & Development
- Chemical Kinetics
- Combustion Noise
- Pollutant Emissions: Modeling, Soot and Particulates
- Combustion Dynamics: Basic Mechanisms, Flame Response to Perturbations, Instability Analysis, Model Development, Nonlinearities and Damping & Control
- Combustion Modeling: Combustor Simulations and Large Eddy Simulations
- High Hydrogen Combustion
- Dry Low-NO_x Combustor Development
- Micro Devices
- Combustor Flows
- Combustor Diagnostics
- Rotating Detonations

Controls, Diagnostics & Instrumentation

The Controls, Diagnostics & Instrumentation (CDI) Committee will host technical, panel, and tutorial sessions that will closely examine, discuss and report on the global challenges and state of the art technologies in the associated technical areas for gas turbine engines and power systems. These will include the latest developments in gas turbine instrumentation and control, diagnostics, prognostics and health management, applications of machine learning and artificial intelligence, data analytics, and the impact these technologies have in improving efficiency and reliability, lowering emissions, and reducing operating costs. More precisely, the exchange of information between experts from Government, Academia and Industry is promoted on the following topics:

- Control System Technology
- Optimal and Intelligent Controls
- Active Component Control
- Distributed Engine Control
- Engine Health Management
- Gas Path Performance Diagnostics
- Structural and Mechanical Component Health Management
- On-Board Engine Monitoring and Diagnostics
- Big Data Analytics for Engine Health Management
- Prognostics for Gas Turbine Engines
- Advanced Data Reduction Methods
- Integrated Controls and Diagnostics
- Modeling for Controls and Diagnostic Applications
- Life Usage Monitoring and Life Extending Control Algorithms and Sensors
- Novel Sensors and Sensor Technologies
- Development of Standard and High Temperature Test Rigs and Probes
- Optical and Non-intrusive Measurement Techniques
- Flow, Temperature, Pressure and Acoustic Instrumentation
- Applications of Machine Learning and Artificial Intelligence in CDI
- CDI Technologies for Hybrid Electric Propulsion Systems

TECHNICAL SESSIONS

Cycle Innovations

The Cycle Innovations Committee is dedicated to the advancement of technology and innovation, with a particular focus on the thermodynamic cycles of gas turbine–based plants for power generation and propulsion. Special attention is also devoted to energy storage technology and management aspects. The Committee traditionally attracts paper submissions from a wide range of disciplines and scientific areas. Some of the thematic areas the Committee currently encompasses are listed below:

- Low or no emissions thermal cycles and advanced CO_2 handling
- Supercritical CO_2 cycles
- H_2 production and utilization
- Polygeneration cycles and process integration (power, heat, cooling, fuels, chemicals)
- Advanced steam and humid air cycles
- Steam and water injection gas turbine cycles
- Closed cycle gas turbine technology
- Novel aero propulsion systems for aircraft and rotorcraft
- Novel marine propulsion systems
- Innovative heat recovery steam generators & once through steam generators
- Renewable and bio-energy concepts and innovative cycles
- Concentrated Solar Power systems incorporating gas turbine technology
- Fuel cell driven cycles and hybrid systems
- Externally fired gas turbines and high temperature heat exchangers
- New cycles for distributed power generation
- Thermo-economic and environmental impact analysis
- Cycle simulation and analysis for performance and health assessment
- Low temperature heat recovery cycles
- Geothermal cycles
- Innovative control systems for power plants
- Optimization of traditional and innovative energy and propulsion systems
- Electrical energy storage
- Thermal energy storage (hot water, phase changing materials, nanomaterials, thermochemical devices, etc.)
- Storage solutions for hydrogen or complex chemicals
- Compressed air energy storage

Authors and presenters are invited to participate in this event to expand international cooperation, understanding and promotion of efforts and disciplines in the area of Cycle Innovations. Dissemination of knowledge by presenting research results, new developments, and novel concepts in Cycle Innovations will serve as the foundation upon which the conference program of this area will be developed.

A variety of sessions are available for presentations as it allows flexibility to the authors. All sessions are quality driven.

Education

Sessions encompass gas turbine/turbomachinery education both in the university and in the industry. Specific teaching tools and techniques will be discussed, including web-based and large-scale remote education, along with industry opportunities for gas turbine engineers. Anyone interested in gas turbine/ turbomachinery engineering education is welcome, from students to academics and professionals. Academics will be exposed to ideas and best practices used at other institutions as well as innovative approaches for gas turbine/ turbomachinery education. Industry will have an opportunity to interact with educators to discuss relevant topic areas and to express their expectations with regard to changing needs. Discussions here have the potential to influence engineering education for a positive impact on future engineers. The sessions provide an active and constructive dialogue about gas turbine/turbomachinery education among practitioners from the industry, students, educators and researchers.

- Education Issues
- Professional Development Workshop for Mid and Late Career Engineers on Transition Coaching

TECHNICAL SESSIONS

Electric Power

The Electric Power Committee (EPC) promotes the exchange of significant technical information on the application and operation of gas turbine power plant systems. The committee organizes technical and tutorial sessions that deal with the current topics in the electric power industry related to the turbine technology, power plant, digital solutions that prevent/reduce forced outages and improve operation efficiency, flexible operations, decarbonization and hybrid solutions etc. Presenters include owner/operators, original equipment manufacturers, industry independent service providers and other research institutions. The EPC also coordinates popular panel discussion sessions such as OEM technology updates, voice of the owners and operators, industry updates with respect to the economic and regulatory boundary conditions and other contemporary topics in electric power generation industry.

Fans & Blowers

Improvements in fans and blowers are means to address the global energy challenge, with manufacturers increasingly focusing on improvement in fan efficiency and the reduction of noise emissions under legislative pressure, as a part of their response to global climate change.

The academia-industry collaboration and the up-front use of Computational Fluid Dynamics (CFD), Experimental Fluid Dynamics (EFD) and Machine Learning (ML) are the key ingredients to facilitate the advancement from traditional empirical design methodologies.

In response to these challenges, the ASMEIGTI Fans and Blowers Technical Committee consider all technical aspects associated with fans and blowers, with a special emphasis on:

- Fans and Blowers: Computational Fluid Dynamics
- Fans and Blowers: Experimental Methods
- Fans and Blowers: Basic Design and Industrial Application
- Fans and Blowers: Optimization
- Fans and Blowers: Machine Learning

Heat Transfer

Heat transfer is a discipline having major influence on technology development of advanced high-performance gas turbines for air-land-sea propulsion and power generation. The heat transfer sessions offered at Turbo Expo 2021 relate to every aspect of the state-of-art gas turbine engine thermal system and management, including details of internal air system and seals design as well as innovative experimental and cooling/heat exchange schemes. This year's conference will include presentations of over 150 technical papers in more than 30 sessions and several tutorials of popular interest.

Heat transfer topics are subdivided into 5 tracks, representing the major subdisciplines within gas turbine heat transfer: Film Cooling, Internal Cooling, Internal Air Systems and Seals (organized jointly with the Turbomachinery Committee), Combustors (organized jointly second with the Combustion, Fuels & Emissions Committee), and Special Gas Turbine Heat Transfer Topics. In addition, a Tutorials track presents background on gas turbine heat transfer for the benefit of all interested conference attendees.

The Film Cooling track consists of 9 sessions and offers a wide range of information detailing recent film cooling research activities that contribute significantly to thermal management of turbomachinery components. Sessions cover novel film cooling configurations, unsteady effects, the relationship between film cooling and advanced materials and manufacturing, and recent improvements in computational methods suitable for advanced film cooling design.

The Internal Cooling track with 5 sessions covers experimental and numerical studies of all aspects of internal cooling technology for the design of turbine blades, vanes, and adjacent hot gas path components. Special emphasis will be placed on rotational effects, impacts of additively manufactured cooling channels, various methods of enhancing heat transfer, and novel cooling analysis techniques.

Internal Air Systems & Seals track (8 sessions), offered jointly with the Turbomachinery Committee, represents the key area of gas turbine internal cooling and sealing technologies. Sessions in this track include papers on hot mainstream gas ingestion, free and forced convection heat transfer on rotating surfaces and in closed cavities, as well as innovative sealing systems and cooling air delivery concepts.

Heat Transfer continued on following page...

TECHNICAL SESSIONS

The Combustors track (2 sessions) is held jointly with the Combustion, Fuels and Emissions Committee. This track presents numerical and experimental studies related to cooling of combustor liners as well as heat transfer aspects and complex flow interactions in combustion systems.

The Special Topic (formerly General) heat transfer interest track with 7 sessions covers experimental and numerical investigations of heat transfer problems specific to areas within the gas turbine as well as all electric/fuel cell powered propulsion, ramjet, and steam turbine systems. This exciting collection of work spans combustion-turbine flow interaction, turbine blade tips, and blade external heat transfer, and covers design methods, tools, and phase change heat exchange systems including heat recovery steam generators. Conjugate/fluid-structural interaction heat transfer methods and novel experimental techniques will also be presented in these sessions.

The Tutorials track (2 sessions) presents fundamental lectures on thermo fluid concepts associated with vorticity and vortex as well as conjugate heat transfer methodologies for combustor applications.

The following is a detailed listing of session content across all tracks.

Film Cooling

- Effects of Thermal Barrier Coatings and Unsteadiness
- Unusual Cooling Configurations
- Leading Edge Film Cooling
- Blade Tip Cooling
- General Experimental Film Cooling
- Endwall Film Cooling
- Computational Predictions of Film Cooling
- Computational Advancements for Film Cooling Flows
- Advanced Materials with Film Cooling

Internal Cooling

- Jet Impingement (Multiple Sections)
- Additive Manufacturing
- Rotating Heat Transfer & Turbulators
- Conjugate Heat Transfer & Optimization

Internal Air Systems & Seals (with Turbomachinery)

- Air System and Seal Design
- Air System Modelling & Validation
- Labyrinth and Finger Seals
- Brush Seals
- Rim Seals (multiple sessions)
- Rotating Cavities (multiple sessions)

Combustors (with Combustion, Fuels & Emissions)

- Combustor Interactions and Reacting Flows
- Combustor Effusion Cooling and Flow Effects

Special Topic Heat Transfer

- Blade Tip Heat Transfer
- Combustor-Turbine Interaction
- External Flow Heat Transfer
- Methods & Technologies (multiple sessions)
- Heat Exchangers with Phase Change

Tutorials

Tutorials of Basics are intended to be presented at a level where a non-expert could learn about fundamentals of a technology area. Past tutorials in the Heat Transfer Committee included topics such as:

- Counter Intuitive Concepts of Thermo Fluids: Vorticity and Vortex
- Conjugate Heat Transfer Methodologies for Gas Turbine Combustor Aerothermal Investigations
- Turbine Cooling Fundamentals
- Physics-Based Introduction to Vortex, Windage, Rothalpy, Mach Number, Choking, Normal Shock, and Entropy Map

TE2021 Tutorials are still being solicited.

TECHNICAL SESSIONS

Industrial & Cogeneration

Representing gas turbine applications within the cogeneration and process industries, technical sessions in this track cover a wide range of topics on cogeneration/CHP (Combined Heat & power) systems, including but not limited to the following: thermoeconomic analysis, optimization and simulation methods, design, operation & maintenance aspect of Heat Recovery Steam Generators, operation & maintenance issues of cogeneration plants, gas turbine power augmentation technologies (inlet chilling, high pressure fogging, and wet compression or overspray, dry/humid air inject, steam injection, etc.), compressor fouling, inlet air filtration systems, compressor washing, gas turbine upgrades and modifications, environmental and regulatory issues, and lessons learned from field experiences.

Other applications such as non-gas turbine based cogeneration/ CHP systems (steam turbine and reciprocating engine based systems, solar energy based systems, etc.), cogeneration and cold energy recovery in LNG plants, hybrid cogeneration systems (combined with fuel cells), integration between gas turbines and renewable generators (including storage technologies) and organic Rankine cycle based systems are also included.

Panel/Tutorial sessions cover topics on cogeneration technologies, compressor washing technologies, inlet air filtration systems, gas turbine power augmentation technologies, dynamic modeling of cogeneration/CHP systems, gas turbine combustion processes and emissions issues, fuel related issues, and impact of Shale energy market.

- Design and Evaluation Considerations of Waste Heat Recovery Technologies
- Thermo-Economic Analysis of CHP/Cogeneration Systems
- Techno-Economic Analysis of CHP Systems
- Operational & Maintenance Aspects
- Gas Turbine Power Augmentation Technologies
- HRSG's Design & Operational Issues
- Inlet Air Filtration for Gas Turbines
- Combustion & Emissions
- Gas Turbine Applications Involving Heavy Fuel Oils and Crude Oils
- Dynamic Modeling of CHP Systems
- Condition monitoring and Diagnostics for CHP Systems
- Gas turbine Integration with Renewable Generators and Storage Technologies
- Renewable Energy
- Hydrogen, Synthetic Methane
- Energy storage
- LCA emissions
- Risk assessment

Manufacturing Materials & Metallurgy

The field of materials and metallurgy associated with gas turbine manufacturing has traditionally been the source of numerous disruptive technologies such as the development of superalloys, precision single-crystal investment casting and ceramic coatings. These in turn have allowed an incredibly accelerated pace of innovation. Next generation materials and processes will allow even higher efficiency and reliability as well as greater flexibility operational mode. A major goal is to balance these with lower emissions and lower life-cycle cost of turbomachinery. Materials with higher strength, lighter weight and improved durability are required for these applications. The continuing development in metallurgy and materials science has resulted in newer materials, better surface protecting methods, and more reliable component life. Development in manufacturing technologies, including better process planning/ optimization, advanced machining operations, additive manufacturing, newer coating and repair methods, helps to reduce the manufacturing cost and decrease overall operating cost of gas turbines. Condition assessment of parts after service and advanced repairs are required to further reduce life cycle cost and impact to the environment. Failure analysis is a key metallurgical tool to investigate shortcomings and identify opportunities to make gas turbine systems more robust.

The MMM committee is organized to disseminate the latest developments and research results in the areas of manufacturing, materials and metallurgy to gas and steam turbine designers, manufacturers, users, repair and service vendors, researchers and consultants. In addition to technical paper sessions, tutorial, lecture and panel sessions are planned where highly experienced panel members will discuss their latest experiences and knowledge in manufacturing methods, repair/coating processes and component inspections.

TECHNICAL SESSIONS

Marine

Gas turbines are increasingly being used in both naval and commercial marine applications. Marine sessions showcase the latest developments and best practices for gas turbines and associated equipment in marine electrical power and propulsion systems. Paper subjects cover a variety of gas turbine related topics ranging among hot corrosion of advanced material, development and testing of hybrid electric propulsion, United States Navy gas turbine engine related upgrades and engineering program reviews, and different innovative marine propulsion systems.

Technical Paper Session Topics include:

- Design and Development
- Applications

Microturbines, Turbochargers & Small Turbomachines

- Microturbines: Component Design and Performance Analysis
- Micro Gas Turbine: Combustion and Fuels
- Microturbines for Distributed Power Generation and Hybrid Energy Grids
- Microturbines and Turbochargers: Emerging System and Application
- Microturbines and Turbochargers: Turbines
- Turbochargers: Design through testing in the loop
- Turbochargers: Turbocharger and internal combustion engine integration
- Turbochargers: Bearing Systems and rotordynamics
- Turbochargers: Compressors

Oil & Gas Applications

The Oil & Gas industry is a large user of turbomachinery. The demand for oil and gas is consistently growing, and changing market conditions require innovative solutions. Operation and optimization of turbomachinery in a variety of Oil & Gas applications is therefore of great interest. Moreover, potentially extreme operation environments require the consideration of innovative design and operational attributes.

Sessions in the Oil & Gas Applications Track address both theoretical and practical Oil & Gas industry perspectives. The technical sessions provide the latest information on gas turbines and compressors in pipeline and compression stations. Particular emphasis is given to design, operation and maintenance, management, dynamic behavior, diagnostics and vibration and noise, as well as to all engineering issues in Oil & Gas applications. Wet gas compression and multi-phase pumping are also addressed, due to the increasing interest in many installations.

The Oil & Gas Applications Committee brings industry experts together in panel and tutorial sessions jointly held by both academic educators and industry professionals. Both basics of Oil & Gas installations and off-design operation issues will be covered, aimed to ensure improved efficiency and safe and reliable operation. The latest information about environmental impact, product upgrade, risk assessment, standards and legislation of gas turbines and compressors in Oil & Gas applications is also provided.

- LNG Applications
- Wet Gas Compression and Multiphase Flow
- Surge, Stall and Critical Conditions
- Systems, Components and Auxiliary Devices Analysis: I
- Systems, Components and Auxiliary Devices Analysis: II
- Performance Degradation
- Diagnostics, Maintenance, Operation
- Performance Analysis
- Power Cycles and Thermodynamics

TECHNICAL SESSIONS

Organic Rankine Cycle Power Systems

The use of an organic fluid in place of water (steam) in Rankine cycles is in general advantageous if the thermal energy source is at low/medium temperature, and/or the thermal power availability is small (few kW to few MW). In these cases the proper selection of the working fluid allows to obtain comparatively higher cycle efficiency, to solve several technological problems, to obtain a more compact design of the expander and to limit the air leakage in the condenser. In the rather new framework of decentralized conversion of low temperature heat into electricity, the Organic Rankine Cycle (ORC) technology offers an interesting alternative, which is partly explained by its modular feature: a similar ORC system can be used, with little modifications, in conjunction with various heat sources such as waste heat, geothermal, biomass combustion or solar power. The technical sessions cover the latest research and operational experience in this field, with a special focus on working fluid, expansion machines design, modeling and optimization issues.

Steam Turbines

Turbo Expo 2021 includes a track dedicated to Steam Turbines. While many of the analyses, computational methods, and experimental techniques are common for steam turbines and gas turbines, there are some unique features on steam turbines that warrant special consideration. Separate, co-located, steam turbine sessions at Turbo Expo provide a natural way of sharing many of the cutting edge technologies while giving the steam turbine community a dedicated forum for the unique technical challenges associated with wet steam, long last stage blades, industrial and co-generation steam turbines, the unique mechanical integrity challenges for steam and more.

The following topics will be addressed:

- Last Stage Blades and Exhausts
- Wet Steam
- Valves & Seals
- Operational Aspects of Steam Turbines
- Mechanical Aspects of Steam Turbine
- General Design Aspects of Steam Turbines

Structures and Dynamics

The expanded use of gas turbines in extreme environments introduces new demands on the structural integrity of aero and industrial gas turbine development and operation.

The program of seven Structures & Dynamics tracks, including (1) Emerging Methods in Design & Engineering, (2) Fatigue, Fracture & Life Prediction, (3) Probabilistic Methods, (4) Rotordynamics, (5) Bearing & Seal Dynamics, (6) Structural Mechanics, Vibration & Damping and (7) Aerodynamic Excitation & Damping, covers highly relevant issues concerning the mechanical integrity of gas turbine engines, compressors, steam and wind turbines as well as turbochargers.

Papers in the Structures and Dynamics Committee deal with best-in-class structural mechanics solutions by contributing fluid, acoustic, thermodynamic, and cooling interactions, which have an impact on the reliability and lifetime prediction or failure-free operation of mechanical components. Modeling and design methodologies based on analytical, numerical, probabilistic and experimental approaches are presented in more than 40 technical sessions organized by internationally recognized industry leaders and academic researchers.

International networking is arranged among all attended engineers, designers and researchers representing industry, academia and government from different countries. All participants benefit from scientific discussions and identification of cutting-edge technological news and trends in mechanical integrity for meeting today's and tomorrow's challenges in gas, steam and wind turbine industry for the best cross-product methodology synergy.

The diversity of subjects covered will boost attendees' knowledge and contribute to their professional career development.

The S&D panel and tutorial sessions, organized in collaboration with other Congress Committees, leverage engineer's knowledge for topics of the highest interest to the international mechanical engineering society.

Structures and Dynamics continued on following page...

TECHNICAL SESSIONS

Emerging Methods in Design & Engineering

- Emerging Methods on Advanced Designs
- Emerging Methods on Structural Design System – Mechanical Analysis
- Emerging Methods on Structural Design System – Dynamics Analysis

Fatigue, Fracture & Life Prediction

- Fatigue Crack Analysis
- Fatigue Damage Analysis
- Constitutive Materials Modelling
- Fretting Fatigue and Corrosion
- Data Driven Life Analysis

Probabilistic Methods

- Probabilistic Methods 1
- Probabilistic Methods 2

Rotordynamics

- Analysis I
- Analysis II
- Modeling improvements I
- Modeling improvements II
- Experiments and special investigations I
- Experiments and special investigations II
- Applications I
- Applications II
- Bearings and Seals I
- Bearings and Seals II
- Gas Turbine Rotordynamics - Practical Aspects
- Introduction to Torsional Rotordynamics
- Rotordynamics - Theory, Vibration Monitoring, and Case Studies
- How to Apply API Standards to Turbomachinery
- Rotordynamics - An Introduction

Bearing & Seal Dynamics

- Gas Bearings 1
- Gas Bearings 2
- Gas Bearings 3
- Gas Bearings 4
- Gas Bearings 5
- Tilting Pad Bearings
- Fluid Film Bearings 1
- Fluid Film Bearings 2
- Magnetic Bearings
- Squeeze Film Dampers
- Seals 1
- Seals 2
- Seals 3
- Seals 4
- Seals 5
- Seals 6
- Seals 7

Structural Mechanics, Vibration & Damping

- Vibration Safety
- Modal Analysis
- Mistuning I
- Mistuning II
- Mistuning III
- Novel Damping Technology
- Friction Damping I
- Friction Damping II
- Nonlinear Phenomena
- Blade-Casing Interactions
- Computational Techniques for Nonlinear Vibrations
- Experimental Techniques I
- Experimental Techniques II

Aerodynamic Excitation & Damping

- Aerodynamic Forcing in Axial Fan and Compressors
- Aeroelastic Stability in Axial Fans and Compressors
- Non-synchronous Vibrations
- Non-Synchronous Vibrations in Fans
- Methods for Aerodynamic Forcing and Damping Prediction
- Aerodynamic Forcing and Damping in Radial Turbomachinery
- Turbine Aerodynamic Forcing and Damping
- Seal Aeroelastic Stability

Supercritical CO_2 Power Cycles

Supercritical CO_2 based power cycles provide significant efficiency and cost of electricity benefits to applications in waste heat, thermal solar, nuclear, and fossil fuel power generation. They also provide for separation, compression, transportation, and storage (geologic) of CO_2 from fossil fuel power plants. The approach to supercritical geologic storage of CO_2 benefits greatly from the existing technology and knowledge amassed around CO_2 utilization and management in the oil & gas industry. While the end goals of the CO_2 based power cycles and the CO_2 storage applications in the oil & gas industry are different, the properties of the working fluid, thermodynamics, technology and machinery used for these applications are very similar.

The confluence of interests related to the use and management of supercritical CO_2 has created an imperative to further the understanding of these applications. The Supercritical CO_2 Power Cycle committee organizes sessions that focus on the dissemination of machinery and cycle related technologies of sCO_2 power plant applications.

- Supercritical CO_2 Turbomachinery
- Supercritical CO_2 Compressors
- Supercritical CO_2 Heat Exchangers
- Supercritical CO_2 Testing
- Supercritical CO_2 Properties and Design Considerations
- Supercritical CO_2 Cycle Optimization
- Supercritical CO_2 Oxy-Combustion
- Supercritical CO_2 Cycle Concepts and Modeling

Turbomachinery

The Turbomachinery Committee of ASME IGTI at Turbo Expo is the premier forum for the world's experts from academia, industry, and government to share advances in the state of the art in turbomachinery aero/thermodynamics technology. Technical paper sessions address aerodynamics topics on fans, compressors, turbines, and ducts in axial, radial and mixed flow configurations. The technical content covers not just a wide range of gas turbine applications for air and marine propulsion and power generation, but also other important sectors such as oil and gas, industrial gas compression, and expanders for waste heat recovery. Design concepts and processes, experimental results, and analytical approaches for modeling with CFD and simpler models are addressed. Design topics include such areas as optimization strategies, endwall profiling, leakage effects, tip clearance effects, quality effects, flow control, casing treatments, unsteady flows, and stall inception and control. Modeling topics include turbulence and transition modeling, LES and DNS, accelerated steady and unsteady formulations, and multi-stage steady CFD, as well as lower-order (non-CFD) models. The increasing emphasis on interaction effects between adjacent components and between multiple disciplines is reflected in specific sessions on these subjects. In addition, several sessions sponsored jointly with other committees focus on important areas of crossdisciplinary interest: with Heat Transfer, sessions on turbine cooling and secondary flow circuits; with Structures, on aeromechanics; and with Aircraft, on noise and acoustics.

Turbomachinery: Axial Flow Fan & Compressor Aerodynamics

- Water Ingestion, Fogging, Pre-Cooling
- Transition & Roughness Effects
- Compressor Experiments
- Manufacturing & Deterioration Effects
- Transonic Compressor Design
- Tandem Aerofoils
- Tip-Clearance Flows
- Design Concepts
- End-Wall Flows & Passage Contouring
- Seal & Leakage Flows
- Flow Control – 1
- Flow Control - 2
- Flow Control – 3
- Casing Treatment - 1
- Casing Treatment – 2
- Stall
- Fan Design - 1
- Fan Design - 2
- Test Rig & Facility Design
- Compressor Design – 1
- Compressor Design – 2

Turbomachinery continued on following page...

TECHNICAL SESSIONS

Turbomachinery: Axial Flow Turbine Aerodynamics

- Loss Generation & Development
- High Fidelity CFD Studies
- Aerodynamic Analyses
- Wakes & Transition
- Purge & Leakage Flows
- Unsteady Flows and Transition
- Flow Control & Tip Seals
- LPT & Turbine Rear Structures
- New Turbine Designs

Turbomachinery: Design Methods & CFD Modeling for Turbomachinery

- LES and DNS Methods and Applications (1)
- LES and DNS Methods and Applications (2)
- Compressor Design Methods and Applications (1)
- Compressor Design Methods and Applications (2)
- Turbine Design Methods and Applications (1)
- Turbine Design Methods and Applications (2)
- Optimization Methods and Applications (1)
- Optimization Methods and Applications (2)
- Preliminary Design Methods (1)
- Preliminary Design Methods (2)
- Preliminary Design Methods (3)
- Radial Turbomachinery Design Methods and Applications (1)
- Cavity, Bearings and Seal Design Methods and Applications (1)
- Fan Design Methods and Applications • Component Interaction and Multi-Physics Coupling (1)
- Novel Solver and Simulation Frameworks (1)
- LES and DNS Methods and Applications (3)
- Novel Solver and Simulation Frameworks (2)
- Cavity, Bearings and Seal Design Methods and Applications (2)
- Methods and Application for Hydrodynamics
- Application and Methods for Unsteady Flow (1)
- Component Interaction and Multi-Physics Coupling (2)
- Geometry Design and Meshing (1)
- Flow Separation, Loss and Boundary Layer Interaction Methods
- Novel Solver and Simulation Frameworks (3)
- Geometry Design and Meshing (2)
- Preliminary Design Methods (4)
- Radial Turbomachinery Design Methods and Applications (2)
- Novel Methods for CFD (1)
- Novel Methods for CFD (2)

Turbomachinery: Noise, Ducts and Interactions

- Compressor and Combustion Noise
- Fan and Engine Noise
- Gas Turbine Engine Intakes, Exhaust Diffusers, and Ejectors
- Gas Turbine Engine Transition Ducts and Flow Interactions

Turbomachinery: Radial Turbomachinery Aerodynamics

- Radial and Mixed Flow Turbines I
- Radial and Mixed Flow Turbines II
- Centrifugal Compressors 1
- Centrifugal Compressors 2
- Centrifugal Compressors 3
- Centrifugal Compressors 4
- Centrifugal Compressors 5
- Centrifugal Compressors 6

Turbomachinery: Unsteady Flows in Turbomachinery

- Unsteady Flows in Compressors I
- Unsteady Flows in Turbines I
- Unsteady Flows in Turbines II
- Unsteady Flows in Turbines III
- Unsteady Flows in Turbines IV
- Stall and Surge I
- Stall and Surge II
- Stall and Surge in Centrifugal Compressors
- Unsteady Flows in Centrifugal Compressors
- Analysis and Processing Techniques for Unsteady Flows
- Unsteady Flows in Compressors II

Turbomachinery: Multidisciplinary Design Approaches, Optimization & Uncertainty Quantification

- Parameterization Approaches
- Manufacturing Tolerances and Uncertainties
- Surrogate-Assisted Approaches,

Turbomachinery continued on following page...

including Sampling and Data Mining
- Axial Compressors, Propellers and Fans
- Turbine Design and Cooling
- Preliminary Design Systems and Approaches
- Adjoint Methods
- Multidisciplinary Optimization and Sensitivity Analysis (fluid, structure)
- Sensitivity Analysis and Design for AM

Turbomachinery: Deposition, Erosion, Fouling, and Icing

- Multi-phase (Water/Ice) Deposition in Gas Turbines
- Modeling Deposition in Turbine Cooling Passages
- Erosion in Turbines
- Deposition Modeling - I
- Deposition Modeling – II

Wind Energy

The rapid expansion of wind power and the steady decrease in the cost of wind-generated electricity has consolidated the position of wind power as an indispensable part of the global energy mix. The Technical Program of the Wind Energy Committee will focus on innovations that are driving technological advances in the wind industry. The technical presentations cover aerodynamics, aeroelasticity, structures and condition monitoring aspects of wind turbines, as well as the interaction of wind turbines with other energy systems. Based on the latest research tendencies, special focus is given this year to offshore wind turbines. These topics are addressed for small and large wind turbines, as well as vertical and horizontal axis wind turbines. For experts and beginners, tutorial sessions will be presented to detail developments and tools that are employed in the rapidly growing wind industry.

The main topics addressed during the Turbo Expo 2021 conference are:

- Latest Developments on Wind Turbine Design
- Blade and Airfoil Aerodynamics
- Vertical Axis Wind Turbines
- Structural Loads, Aeroelasticity and Noise
- Condition Monitoring and Reliability
- Wind Turbine Simulation Methods and Applications
- Flow Control and Smart Wind Turbines
- Offshore wind turbines

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EXHIBIT AT ASME TURBO EXPO 2021

BECOME A VIRTUAL EVENT EXHIBITOR

We still need and want to connect with exhibitors who can bring us new products, enhanced services, and solutions to better serve the turbomachinery community. ASME Turbo Expo Virtual gives you a way to still connect.

We plan to have the ASME Turbo Expo Virtual event during the week of June 7-11. A registration allows for participation in the keynote, paper sessions, poster session and discussions. But even beyond the paper sessions that week, we are encouraging the registrants to go online at their convenience 24-7 to check out the exhibition. Just think, every attendee from around the world can now check out your company personally when its most convenient for them during the Live event and for 90 days after!

So, thank you for considering becoming a virtual exhibitor or sponsor of the ASME Turbo Expo Virtual Conference and Exhibition! We hope to continue our tradition of our annual face to face event in June 2022 in Rotterdam.

Virtual Show Participation Benefits include:

- Wider Audience Reach (Geographically)
- Deeper Audience Reach (Positions within the Industry that might not make a face to face event)
- Longer Selling Time with a Week Before, During, and 90 Days After the Event
- Great Branding and Sponsor Opportunities
- Opportunity to Make Connections and have Conversations to Capture New Leads
- Include Videos of your Latest Products, Add Photos and make Comments in Your Show News Feed

Exhibition Information

Book your virtual space now. Branding, visibility, and showcase opportunities available before, during and after the virtual conference. To request to join the virtual exhibition and engage with the global turbomachinery audience, send an email to *igtiexpo@asme.org* today.

$1200 Virtual Booth - Load images, videos, presentations, and up to 5 downloadable content documents in your virtual booth. Includes lead generation and one technical conference badge. Attendees can start conversations with exhibitors using email and/or video chat, in a one to one chat or group chat setting. Your logo with a Web link and 15-word description will be on the exhibitor page of the ASME Turbo Expo Virtual Website in addition to the platform virtual booth. During the event, your logo will be visible for attendees to encourage visiting you in the exhibition. After the event, you will be provided a detailed report showing how many people visited, the content that was reviewed, and more.

We are committed to ensuring that ASME members and the turbomachinery community have access to the latest products and services that will assist in restoring business as quickly, efficiently, and profitably as possible.

A VIRTUAL TRADE SHOW JUST LIKE A PHYSICAL EXPO HALL: TO SEE INNOVATIONS AND MAKE CONNECTIONS; TO GROW SALES AND PROFITABILITY.

BECOME A VIRTUAL EVENT SPONSOR

Just like an in-person event, your sponsorship is the key to gaining visibility, breaking through to reach target customers and prospects, and showing your support for the industry. Now more than ever, your sponsorship makes all the difference!

See the below cost-effective marketing opportunities. Bring prospects to you with sponsorships, branding, and advertising!

Become a sponsor today by completing and returning the *Sponsorship Form*.

Platinum Club: $10,000 USD (Limit 3)

- Sponsor booth in exhibition hall
- 4 complimentary virtual event badges
- Company logo in event emails
- Branding on the Turbo Main Stage where all attendees check in
- Opportunity to send a targeted email to registered attendees
- Social media post with logo on social channels by ASME
- Event push notification encouraging attendees to visit your booth
- Logo on ASME Turbo Expo Virtual Event Website
- 20 content pieces available for downloadin your booth
- Logo on Show Registration/Login page

Gold Club: $7,500 USD (Limit 4)

- Sponsor booth in exhibition hall
- 3 complimentary virtual event badges
- Company logo in event emails
- Opportunity to send a targeted email to registered attendees
- Social media post with logo on social channels by ASME
- Logo on ASME Turbo Expo Virtual Event Website
- 15 content pieces available for download in your booth
- Logo on Show Registration/Login page

Silver Club: $5,000 USD (Limit 5)

- Sponsor booth in exhibition hall
- 3 complimentary virtual event badges
- Company logo in event emails
- Opportunity to send one targeted email to registered attendees
- Social media post with logo on social channels by ASME
- Logo on ASME Turbo Expo Virtual Event Website
- 10 content pieces available for download in your booth
- Logo on Show Registration/Login page

Bronze Club: $2,500 USD (SOLD)

- 2 complimentary virtual event badges
- Company logo in event emails
- Opportunity to send one targeted email to registered attendees
- Social media post with logo on social channels by ASME
- Logo on ASME Turbo Expo Virtual Event Website
- 8 content pieces available for download in your booth
- Logo on Show Registration/Login page

ADDITIONAL VIRTUAL SPONSORSHIP OPPORTUNITIES

Virtual Networking Break

For great conference visibility, sponsor the conference breaks. Select the day of your choice. You may have a 60-second video presentation loop during the breaks of the day.

($3,000.00) Limit one daily sponsor.

Tutorial Sponsor

Opportunity to sponsor the educational tutorials – a 60-second video will play on the tutorials landing page.

($2000.00) Limit 1 sponsor.

Women In Turbomachinery Social

Support the women in the industry. Our first virtual gathering for women will include a speaker and networking. 2-minute video and logo placement from sponsor.

($1500.00) Limit one sponsor.

Now more than ever, your sponsorship makes all the difference!

Student Poster Competition

Opportunity to sponsor the student poster competition – a 60-second video will play on the poster landing page.

($750.00) Limit 1 sponsor.

Virtual Event Supporter

For logo placement, join us a virtual event supporter and have your logo on the Turbo Expo Webpage as well as on the Turbo Main Stage during the Virtual event.

($500.00) Limit six sponsors.

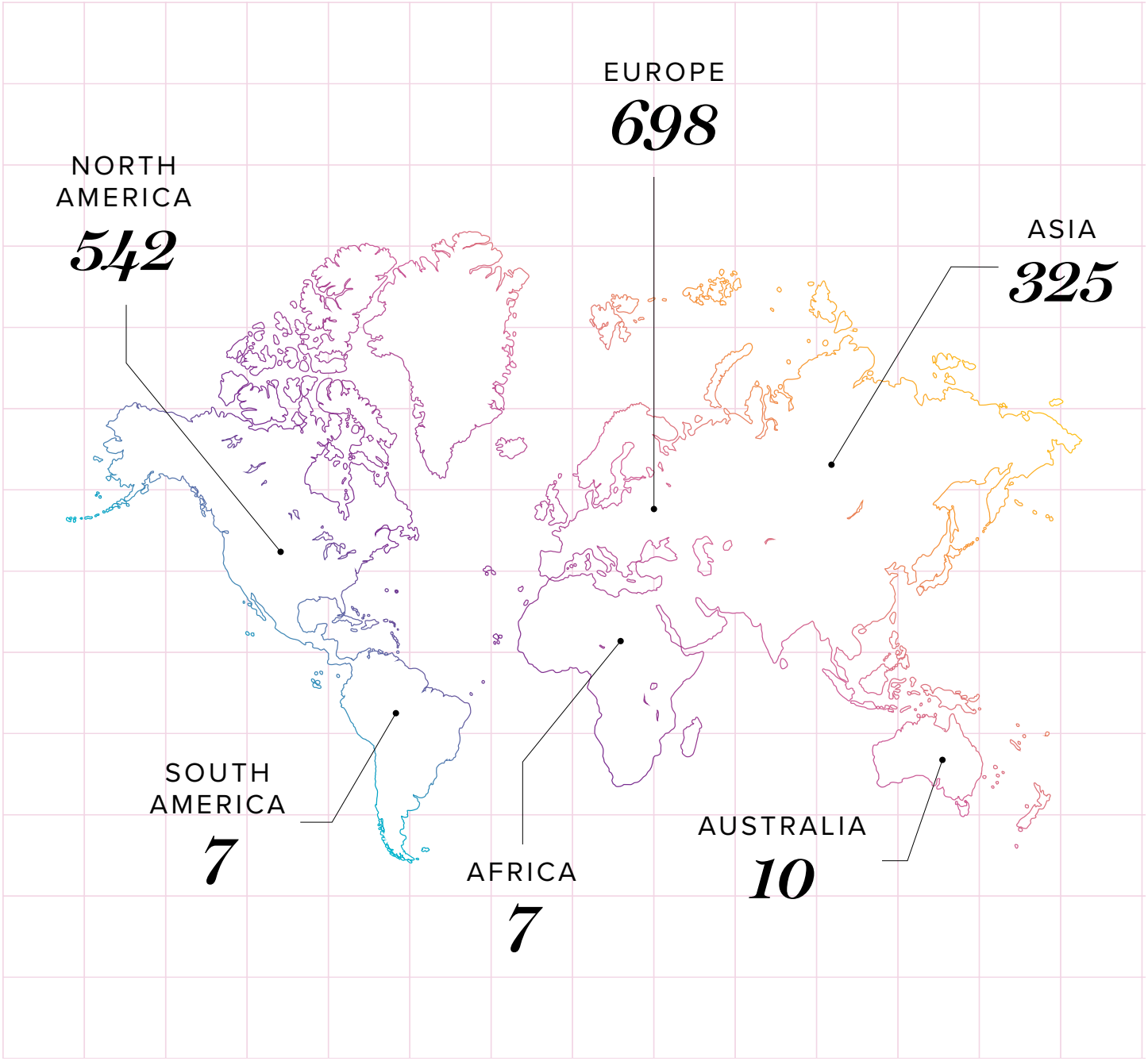
NETWORKING EVENTS

Networking during the conference is an effective method of marketing that is used to build new business contacts through connecting with other like-minded individuals. Make sure you attend all of the virtual networking opportunities during the event.

WOMEN IN ENGINEERING NETWORKING EVENT

VIRTUAL EVENT

Female registrants are invited to join their colleagues for a virtual networking event. Attendees will have the opportunity to network with women in the industry and learn about the career paths of some successful women in the industry. Further details will be available on the Turbo Expo 2021 Final Program.



INDUSTRY PARTICIPANTS

ASME Turbo Expo is proud to have over 1,500 Industry participants from all over the world. These individuals are active within the technical conference and participate as authors, panelists, reviewers, session organizers, session chairs, etc.

REGISTRATION INFORMATION

Be sure to register for ASME Turbo Expo as soon as possible to avoid delays in accessing the virtual event platform as well as access to the on-line paper site. Continue reading to see the full details on rates and benefits.

REGISTRATION

Please be aware of the spamming non-official vendors contacting you. ASME does **NOT** sell or share the conference attendee list with anyone.

Registration Type	REGISTRATION Rate	REGISTRATION Rate Type
* ASME Member	399	Full Registration Rate
ASME Non-Member	449	Full Registration Rate
** Student ASME Member	299	Discounted Rate
Student ASME Non-Member	339	Discounted Rate
ASME Life Member	299	Discounted Rate

Virtual Conference Registration Includes...

- Online access to the TE21 Final Papers
- Online access to the Keynote Session
- Online access to Plenary Sessions
- Online access to Technical Paper Sessions
- Online access to the Student Poster Session
- Online access to the Virtual Exhibition
- Online access to Tutorial of Basics Sessions
- Online access to Panel Sessions

All virtual event content will be available on-demand approximately one week prior to, during and after the virtual event conference dates.

Presenting Author Registration Information

- **Registration deadline date March 23, 2021**
  - All presenting authors must register by March 23, 2021 so that the paper is published.
    - Contact *igtiprogram@asme.org* with any inquiries regarding the Presenting Author registration deadline date of March 23, 2021.
- All Presenting Authors must pre-record a video presentation and register to be published.
  - Presenting authors do not have to be available for the live question & answer session for the paper to be published.
  - If your company does not authorize a pre-recorded video, contact *igtiprogram@asme.org*.
- All Presenting Authors can register to present a total of two (2) papers.
- There must be one (1) full paid registration for each Technical Paper.

Cancellation Policy: *No refunds offered for virtual conference registrations.*

Substitutions: *Registrations may not be transferred or substituted at any time.*

Material presented at ASME conferences is under copyright of ASME. Participants are prohibited from recording, screen-capturing or photographing presentations in their entirety with the intent to distribute to others.

Avoid Registration Delays!

Confirm your existing ASME membership status now or **join/renew your membership** to register at the reduced member rate.

- Contact *customercare@asme.org* to confirm or renew your ASME membership.
- Allow approximately one week to process/renew memberships.

Ensure that your Username and Password is the same for BOTH your paper submission account as well as your membership account.

* The following may register at the discounted Member rate(s):

- ASME Members
- Active Military Personnel
- Point Contacts, Vanguard Chairs
- Session Chairs, Session Co-Chairs
- Authors, Presenters, Speakers
- ASME IGTI Committee Members
- Members of Reciprocating or Participating Organizations

If you are not a current ASME member and meet one of the criteria listeed above, contact *igtiprogram@asme.org* to obtain the member rate discount code.

** Student Registration Rates

Only available to undergraduate and graduate students who are enrolled full time and have not yet received their Ph.D. Post-docs may not register as students.

Free ASME Membership

The following Full Registration Rate paid registrants will receive a free one-year ASME membership:

- ASME Non-Member
- Student Non-Member

ASME will contact eligible registrants to join ASME within 90 days after the conference. For more information, visit *ASME Membership website*.

LEADERSHIP TEAM

ASME Gas Turbine Segment Leadership Team

Mark Zelesky
Vice Leader, TEC Liaison
Pratt & Whitney

Zolti Spakovsky
Member
MIT

Nicole Key
Leader
Purdue University

Daniela Gentile
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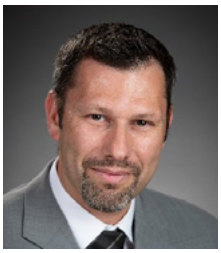
Imperial College London



Akin Keskin
Head of DaVinci Programme
Rolls Royce

STUDENT NEWS

STUDENT NEWS

The Student Advisory Committee (SAC) is a group of students who work to foster student engagement in the IGTI community and improve the Turbo Expo conference every year. Towards this goal, the SAC organizes various sessions and events during the conference, provides opportunities for students to work behind the scenes with leaders in their technical area, and awards travel funds to eligible degree seeking individuals.

Poster Session

The Student Advisory Committee is once again sponsoring a student poster session at ASME Turbo Expo. Student posters will be virtual. Be sure to join the poster session to see the results of their work and encourage them to become active in the ASME IGTI community. Further details will be available in the final program.

CASH PRIZES FOR POSTER SESSION WINNERS

1st Place	$500
2nd Place	$250
People's Choice	$100

SAC Committee Members

Chair

Deepanshu Singh
University of Oxford, UK

Vice Chair

Mavroudis Kavvalos
Mälardalen University, Sweden

Secretary

Manas Payyappalli
Indian Institute of Technology Bombay

Past-Chair

Shawn Siroka
Penn State University

Student Paper Review Initiative Chair

Curtis Stimpson
Honeywell

Student/Early Career Mixer

VIRTUAL NETWORKING EVENT

This popular event allows students to make new friends and build their professional network through a virtual social event. Further details will be available in the final program.

SAC Sessions at Turbo Expo

The sessions organized by the SAC during the technical conference are focused on professional development and are open to all conference attendees. In previous years, the SAC has curated panel sessions led by community leaders on Turbomachinery Careers and Networking, as well as tutorial sessions titled "Effective Technical Presentations", and "The Art of the Peer Review Process".

TUTORIALS OF BASICS

A Tutorial of Basics session covers a basic topic within the coverage area of a technical committee track. The goal of these sessions is for a typical Turbo Expo conference attendee to understand the basics in that particular area.

TUTORIALS

Aircraft Engine

- Basics of Turboshaft Engine Cycle Design and Optimization
- Introduction to Fatigue Life Modeling
- Preliminary Engine Design

Coal, Biomass, Hydrogen & Alternative Fuels

- Life Cycle Assessment Basics and Application to Optimize the Environmental Sustainability of Gas Turbines During New Product Development

Combustion, Fuels & Emissions

- Combustion Dynamics Tutorial
- Combustion Fundamentals

Cycle Innovations

- Power Plant State of the Art Solutions for Enhanced Flexibility and Energy Storage

Cycle Innovations: Energy Storage

- Overview of Grid-Scale Energy Storage Systems and Technologies
- Hydrogen for Power and Energy Storage

Fans and Blowers

- Artificial Neural Networks: From Basics to Turbomachinery Applications

Industrial & Cogeneration

- Combustion and Emissions Tutorial

Manufacturing Materials & Metallurgy

- Data Infrastructure and Digital Twinning Concepts for Advanced Turbomachinery Manufacturing
- Gas Turbine Coatings
- Industrial Internet of Things, Digital Twin and How to Integrate One of Its Most Valuable Data Sources: NDE
- Material and Manufacturing Considerations in Component Lifing Technologies
- Materials Selection for Turbomachinery in Oil and Gas Applications
- Metallurgy for the Non-Metallurgist

Oil & Gas Applications

- Industrial Gas Turbines
- Oil and Gas Applications for Turbomachinery
- Wet Gas Compression Considerations

Structures and Dynamics: Emerging Methods in Design & Engineering

- Deep Science: Applying Modern Approaches to Model Composition and Machine Learning for Engineering Simulation, Analysis, and Design

Structures and Dynamics: Fatigue, Fracture & Life Prediction

- Introduction to Fatigue Life Modeling

Structures and Dynamics: Rotordynamics

- How to Apply Api Standards to Turbomachinery Rotordynamics - an Introduction
- Introduction to Rotordynamics Fundamentals, Measurements, and Phenomena
- Rotordynamics 101: Introduction to Basic Principles of Rotordynamic Theory

TUTORIALS

Supercritical CO2

- Direct-Fired SCO2 Oxy-Combustion
- Heat Exchangers for Supercritical CO2 Power Cycle Applications
- Materials for Supercritical Carbon Dioxide Applications
- SCO2 Turbomachinery Design Tutorial

Turbomachinery: Multidisciplinary Design Approaches, Optimization, and Uncertainty Quantification

- Introduction to Probabilistic Analysis and Uncertainty Quantification
- Uncertainty Quantification With Complex Data

Turbomachinery: Tutorials

- Introduction to Cycle Design of Conventional and Hybrid-Electric Aero Engines
- Machine Learning for Turbomachinery
- Secondary Flows in Turbomachinery
- Tutorial: Introduction to Dry Gas Seals and Systems

Wind Energy

- Recent Developments in Wind Turbine Technology and Research

INSTABILITIES EVERYWHERE! HARD PROBLEMS IN AERO-ENGINES

Many of the challenges that limited aero-engine operation in the 1960s, 70s and 80s were mostly static in nature: hot components exceeding temperature margins, stresses in the high-speed rotating structure approaching safety limits, and turbomachinery aerodynamic efficiencies missing performance goals. Modeling tools have greatly improved since, mostly due to better computers enabling large simulations of the fluid flow and supporting structure, and have helped enhance jet engine design. The situation is thus different today, where most problems encountered past the design and development phases are dynamic in nature. These can jeopardize engine certification and lead to major delays and increased program cost.

A real challenge is the characterization of damping and the related dynamic behavior of rotating and stationary components and assemblies, and of the fluid-structure interactions and coupling. The theme of this lecture is instability in the broadest sense. A number of problems of technological interest in aero-engines are discussed with focus on modeling and identification of the underlying mechanisms. Future perspectives on outstanding seminal problems and grand challenges are also given.

By Zoltan S Spakovszky

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. Spakovszky is Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology and the director of the Gas Turbine Laboratory. He obtained his Dipl. Ing. degree in Mechanical Engineering from the Swiss Federal Institute of Technology (ETH) Zürich and his MS and Ph.D. degrees in Aeronautics and Astronautics from MIT.

Dr. Spakovszky's principal fields of interest include propulsion and energy conversion, internal flows in fluid machinery, compressor aerodynamics and stability, micro-fluidics and rotordynamics, aero-acoustics, aircraft design for environment, and electrified aviation. He currently directs analytical and experimental research in these areas and teaches graduate and undergraduate courses in thermodynamics, propulsion and fluid mechanics, and aero-acoustics.

He has authored a large number of technical papers in refereed journals and has been awarded several ASME International Gas Turbine Institute best paper awards, the ASME Melville Medal, the ASME Gas Turbine Award, the ASME John P. Davis Award, a NASA Honor Award, several Aero-Astro Undergraduate Advising / Teaching Awards, and the Ruth and Joel Spira Award for Excellence in Teaching.

Dr. Spakovszky is a technical consultant to industry and government agencies, a Fellow of the ASME, the Vice Leader of the ASME Gas Turbine Segment Leadership Team, an Associate Fellow of the AIAA, and served as the chair of the turbomachinery committee and review chair of the ASME International Gas Turbine Institute, and as an associate editor for the ASME Journal of Turbomachinery.

TWO DECADES OF US DOE GAS TURBINE RESEARCH AND INNOVATION

By Richard A. Dennis

NATIONAL ENERGY TECHNOLOGY LABORATORY

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 support US university, industry and U.S. national laboratory research, development and demonstration projects.

Rich has a Bachelor and Master of Science degrees 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 a Technology Manager. Currently Richard is serving as the Technology Manager for Advanced Turbines and Supercritical Carbon Dioxide Power Cycles programs at NETL. Additionally, Richard was the 2018-19 leader of the American Society of Mechanical Engineers (ASME) Gas Turbine Segment (GTS). Richard is an ASME Fellow.

TURBINE INNOVATIONS FOR SMALL CORE ENGINES

By Guillermo Paniagua

PURDUE UNIVERSITY

Guillermo Paniagua has pioneered innovative turbine research in transonic turbines and counter-rotating turbines. He demonstrated pulsating trailing edge blowing method to control shock waves and manage the base flow pressure. He invented a new generation of turbines that can operate under high supersonic inlet conditions: supersonic axial, supersonic radial outflow turbines, and bladeless axial turbines. Based on experimental studies of large variations in heat flux on the turbine rotor casing, he co-invented several turbine rotor over-tip concepts that resulted in three patents, enhancing turbine efficiency. After 18 years at the prestigious von Karman Institute, he joined Purdue in 2014 and founded the Purdue Experimental Turbine Aerothermal Lab, developing a tri-sonic turbine facility with modular test sections to enable TRL1 to 6. Professor Paniagua's research is encapsulated in 100 journal articles and182 proceeding papers at leading conferences.

Prof. Paniagua holds an MSc in Electro-Mechanical Engineering (Spain), a Research Master from the von Karman Institute (Belgium), and a Ph.D. with highest distinction in Engineering from the Universite Libre de Bruxelles (Belgium). Since 2016 he is a Part-time Faculty Research Participant in the ORISE program at the National Energy Technology Laboratory.

We will be recognizing the 2020 and 2021 award winners during the 2021 Virtual Event.

SCHEDULE AT A GLANCE

JUNE 7 Monday	JUNE 8 Tuesday	JUNE 9 Wednesday	JUNE 10 Thursday	JUNE 11 Friday
Welcome & Keynote 8:00 - 9:30am	***Plenary: Opening up the Design Space to Afford Efficient Gas Turbines Using H_2 and Biofuels*** 8:00 - 9:00am **Awards** 9:00 - 9:30am	***Plenary: Opening up the Design Space Through Computations and Machine Learning*** 8:00 - 9:00am **Awards** 9:00 - 9:30am	***Plenary: Engineering in 2030 – How Must Our Educational Programs Change to Better Equip the Needed Workforce*** 8:00 - 9:00am **Awards** 9:00 - 9:30am	**Scholar Lecture by Dr. Zoltan S Spakovszky, MIT** 8:00 - 9:00am **Awards** 9:00 - 9:15am **See YOU in 2022!** 9:15 - 9:30am
Break – Visit the *Exhibits, Sponsors*, *Student Posters*, Create your own Roundtable Discussions 9:30 – 9:45 am				
Live 5-Paper Session **2-Deep Dive Talks** 9:45 – 10:45am **3-Rapid Talks** 10:45 - 11:15am	**Live 5-Paper Session** **2-Deep Dive Talks** 9:45 – 10:45am **3-Rapid Talks** 10:45 - 11:15am	**Live 5-Paper Session** **2-Deep Dive Talks** 9:45 – 10:45am **3-Rapid Talks** 10:45 - 11:15am	**Live 5-Paper Session** **2-Deep Dive Talks** 9:45 – 10:45am **3-Rapid Talks** 10:45 - 11:15am	**Live 5-Paper Session** **2-Deep Dive Talks** 9:45 – 10:45am **3-Rapid Talks** 10:45 - 11:15am
Lunch, Dinner, Midnight Snack, *Student Posters*, Visit *Exhibit & Sponsors*, or Create your own Roundtable Discussions 11:15am – 12:15pm	**Women in Engineering Networking Event** 11:30am – 12:00pm **Lunch, Dinner, Midnight Snack, *Student Posters*, Visit *Exhibit & Sponsors*, or Create your own Roundtable Discussions** 11:15am – 12:15pm	**Lunch, Dinner, Midnight Snack, *Student Posters*, Visit *Exhibit & Sponsors*, or Create your own Roundtable Discussions** 11:15am – 12:15pm		
Live 5-Paper Session **2-Deep Dive Talks** 12:15 – 1:15pm **3-Rapid Talks** 1:15 – 1:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 12:15 – 1:15pm **3-Rapid Talks** 1:15 – 1:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 12:15 – 1:15pm **3-Rapid Talks** 1:15 – 1:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 12:15 – 1:15pm **3-Rapid Talks** 1:15 – 1:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 12:15 – 1:15pm **3-Rapid Talks** 1:15 – 1:45pm
Break – Visit the *Exhibits, Sponsors*, *Student Posters*, Create your own Roundtable Discussions 9:30 – 9:45 am				
Live 5-Paper Session **2-Deep Dive Talks** 2:15 – 3:15pm **3-Rapid Talks** 3:15 – 3:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 2:15 – 3:15pm **3-Rapid Talks** 3:15 – 3:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 2:15 – 3:15pm **3-Rapid Talks** 3:15 – 3:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 2:15 – 3:15pm **3-Rapid Talks** 3:15 – 3:45pm	**Live 5-Paper Session** **2-Deep Dive Talks** 2:15 – 3:15pm **3-Rapid Talks** 3:15 – 3:45pm
Break – Visit the *Exhibits, Sponsors*, *Student Posters*, Create your own Roundtable Discussions 9:30 – 9:45 am				
Live 5-Paper Session **2-Deep Dive Talks** 4:00 – 5:00pm **3-Rapid Talks** 5:00 – 5:30pm	**Live 5-Paper Session** **2-Deep Dive Talks** 4:00 – 5:00pm **3-Rapid Talks** 5:00 – 5:30pm	**Live 5-Paper Session** **2-Deep Dive Talks** 4:00 – 5:00pm **3-Rapid Talks** 5:00 – 5:30pm	**Live 5-Paper Session** **2-Deep Dive Talks** 4:00 – 5:00pm **3-Rapid Talks** 5:00 – 5:30pm	**Live 5-Paper Session** **2-Deep Dive Talks** 4:00 – 5:00pm **3-Rapid Talks** 5:00 – 5:30pm

SCHEDULE SUBJECT TO CHANGE