

A detailed, close-up photograph of a turbine engine's compressor section. The image shows several rows of highly polished, curved compressor blades, creating a complex, repetitive geometric pattern. The lighting highlights the metallic texture and the precision engineering of the components. A semi-transparent maroon rectangular box is overlaid on the right side of the image, containing white text.

TEXAS A&M ENGINEERING EXPERIMENT STATION

TURBOMACHINERY LAB

The Turbomachinery Symposium was established in 1972 by and for working engineers who were struggling with new problems accompanying the abrupt increase in size and power of turbomachinery in chemical plants on the Gulf Coast. The TURBO (and related PUMP) symposia continue to address real industrial turbomachinery problems through educational programs that have been developed by active advisory committee members. The advisory committees are a productive blend of users, OEMs, consultants, and service providers. The committee members know the problems and know the “players” in developing programs that address and resolve problems.

The Turbomachinery Laboratory (TL) was established in 1982 by faculty members within the college of engineering at Texas A&M University (TAMU). These faculty members had overlapping and complementary interests regarding issues of performance and reliability of turbomachinery and propulsion devices. At present, the TL faculty members have a broad and multidisciplinary range of expertise related to thermal fluid sciences, solid mechanics, materials, dynamics, vibrations, and modern optical diagnostic techniques. They study issues related to, for example, liquid rocket engines, injection compressors, power generation and aircraft gas turbines, steam turbines, a range of centrifugal pumps, and solid rocket motors. Funds from the turbomachinery symposia continue to provide major support for both research and instruction by the TL faculty.

Dr. Eric Petersen
Turbomachinery Laboratory Director



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WHAT IS THE TURBOMACHINERY LABORATORY?

The Turbomachinery Lab, a center of the Texas A&M Engineering Experiment Station (TEES), conducts basic and applied research into important problems of reliability and performance of turbomachinery—rotating machinery that extracts or adds energy to fluids. That’s everything from the classic Dutch windmill to the space shuttle’s main engine turbopumps and compressors that move natural gas through the distribution system.

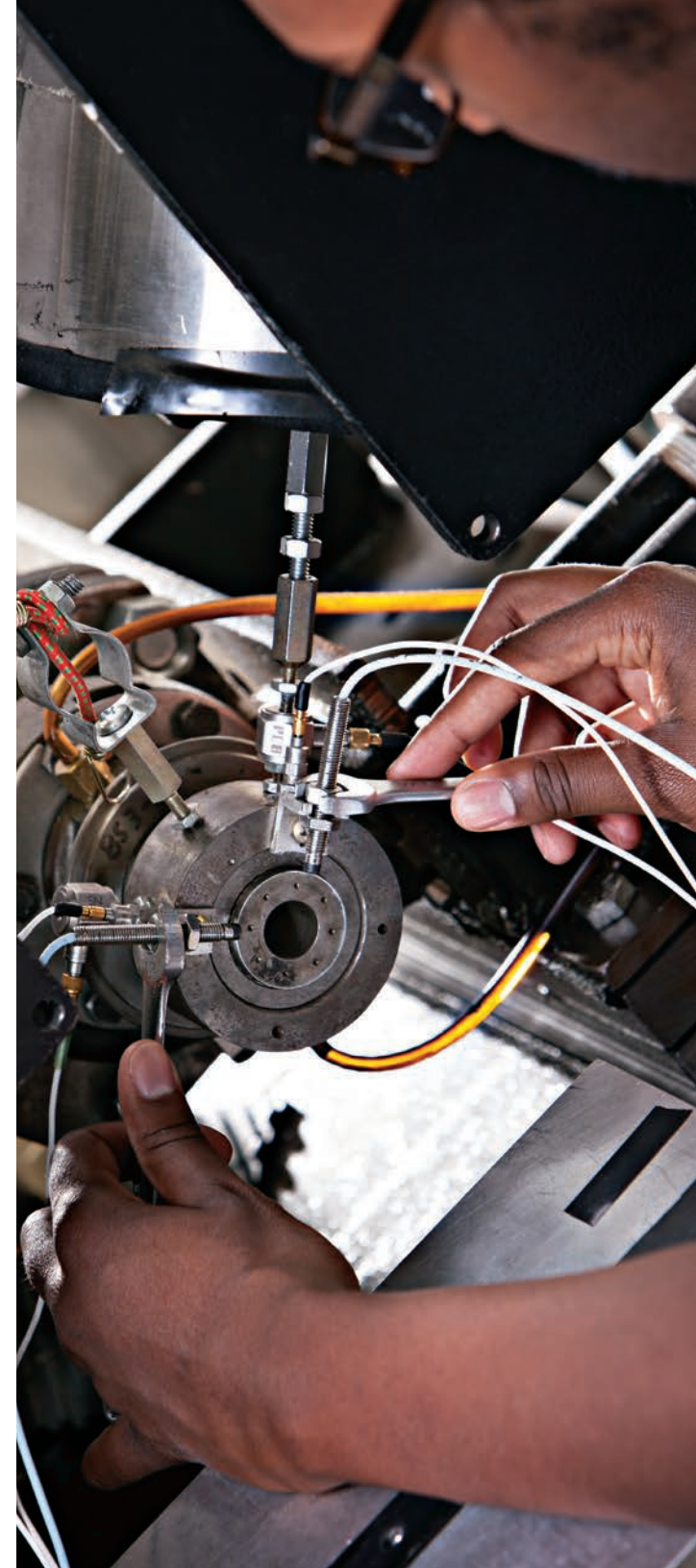
The Turbo Lab, established in 1982, continues to address the needs of users and manufacturers of turbomachinery and pumps. The Turbo Lab is proud to continue Texas A&M University’s land-grant charter and tradition of attention to industry needs in three areas:

- Basic & Applied Research
- Undergraduate & Graduate Education
- Continuing Education & Professional Development

The Turbo Lab offers graduate engineering coursework through Texas A&M’s College of Engineering, and provides continuing education opportunities to users of turbomachinery and pumps all over the world. Opportunities include short courses led by world-renowned researchers and original equipment manufacturers and users, as well as highly-regarded symposia in Houston, Texas, and Southeast Asia.

The Turbo Lab also boasts a unique opportunity for turbomachinery developers and users to find answers to important questions about performance and reliability with the Turbomachinery Research Consortium (TRC).

Learn more about the Turbo Lab at turbolab.tamu.edu.



OUR HISTORY

The Turbomachinery Symposium was first organized in 1972 to directly address urgent issues driven by rapid expansion of ethylene plants in the Houston, Texas area. Increases in horsepower and pressure requirements in steam turbines resulted in ongoing failures and instability in plants resulting in billion-dollar-plus annual losses. The need to solve these problems prompted several industry leaders to collaborate on an effort envisioning a conference in which users and manufacturers could discuss the state of the business, systemic problems, and future solutions.

Two of the leaders in this effort, Charlie Jackson with Monsanto, and Ed Nelson with Amoco, had close ties to Texas A&M University, and negotiated a partnership with the world-renowned research and teaching institution that has resulted in a successful ongoing program under Turbo Lab leadership. The vision of creating a continuing education program driven by industry, for industry, was a novel approach and has secured the success of the Turbo Lab symposia through longtime

industry support. Advisory committees originally consisting of only end-users, later adding manufacturers and consultants, were established to develop a sound technical program through a peer review process.

The purpose of the symposium was clearly stated in its articles of organization:

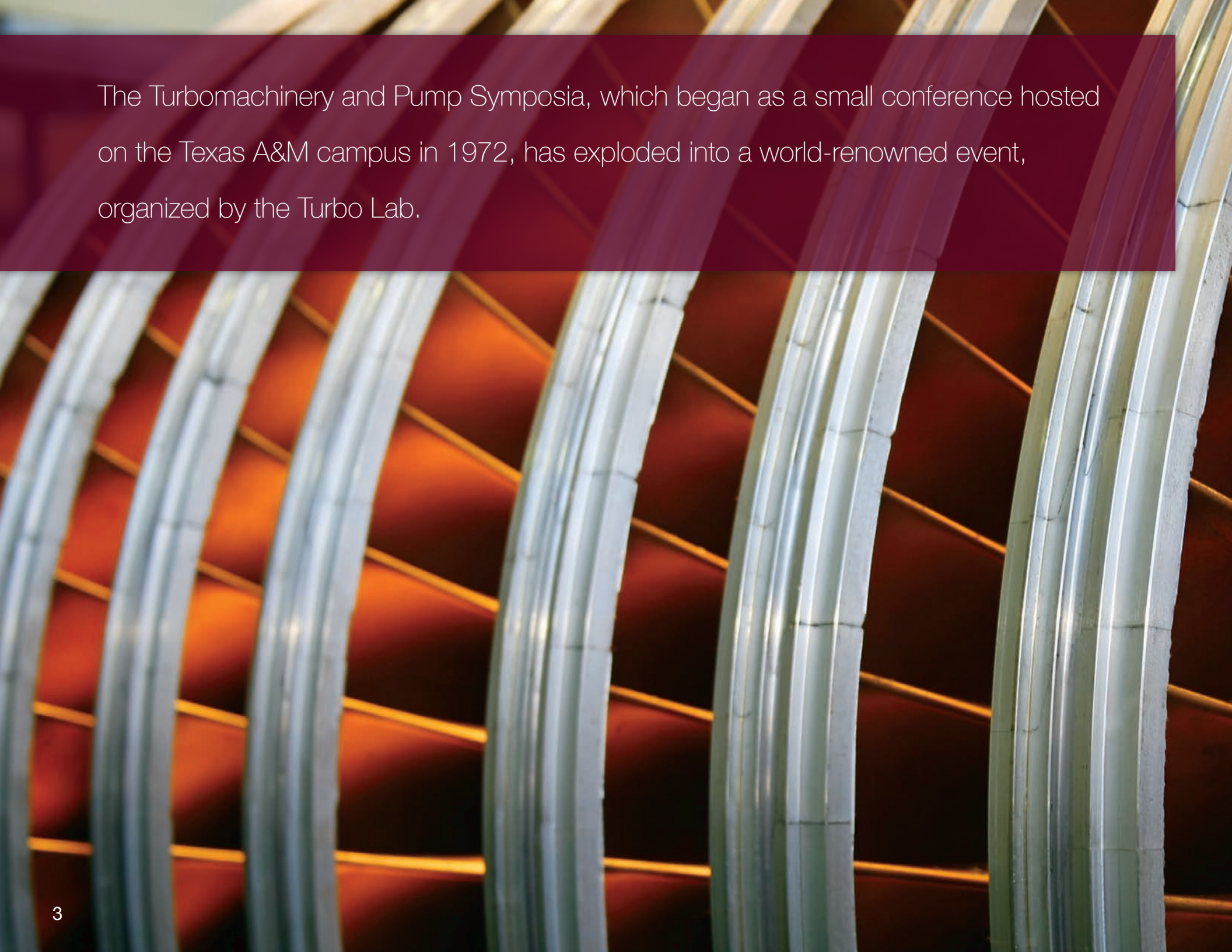
This Symposium shall provide an opportunity for interested persons to learn the applications and principles of various types of turbomachinery and related subjects, to enable them to keep abreast of the latest developments in this field, and to provide a forum for the exchange of ideas. The Symposium shall be on a practical engineering level.

A second symposium, the International Pump Users Symposium was later organized to address specific issues within pump-related industries driven by Clean Air Act regulations in the United States, which necessitated improvements in pump design and operation. The Pump Symposium was combined with the Turbomachinery

Symposium in 2011 to form a single event, the Turbomachinery and Pump Symposia (TPS), held at the George R. Brown Convention Center in Houston. TPS is one of the few, if not only, conferences where end-users have primary influence on technical content, where related events are manufacturing or academically driven. Strong participation and direction from advisory committee members continues to be the primary reason for perennial success with direct industry relevance of the Turbo Lab symposia.

In 2016, the Turbo Lab hosted its inaugural Asia Turbomachinery and Pump Symposium (ATPS) in Southeast Asia. Like TPS, ATPS offers a world-class educational forum in combination with an international exhibition for working engineers in both the turbomachinery and pump industries.

Additionally, the Turbo Lab hosts multi-day short courses in Houston, Texas, and Southeast Asia throughout the year.

A close-up photograph of a turbine or compressor rotor. The image shows several curved, metallic blades arranged in a circular pattern. The blades are illuminated from the side, creating a strong contrast between the bright, reflective surfaces and the dark, shadowed areas between them. The lighting is warm, with a reddish-orange glow. The background is dark, making the metallic surfaces stand out.

The Turbomachinery and Pump Symposia, which began as a small conference hosted on the Texas A&M campus in 1972, has exploded into a world-renowned event, organized by the Turbo Lab.

RESEARCH FACILITY

Turbo Lab faculty, staff and students conduct cutting-edge research for industry and government entities in a state-of-the-art facility located on George Bush Drive in College Station, Texas, adjacent to the university's main campus. The 37,000 square foot high-bay facility is equipped with 12 top-of-the-line vibration damped test cells and a variety of compressors that provide air for test rigs with capacities ranging from 4000 standard cubic feet per minute (scfm) at 120 pounds per square inch gauge (psig) to 1350 scfm at 300 psig. An adjacent reciprocating compressor rig features connections for high-pressure air.

BASIC & APPLIED RESEARCH

Industrial research support is provided, in part, by the Turbomachinery Research Consortium (TRC).

TURBOMACHINERY RESEARCH CONSORTIUM (TRC)

The TRC is an exclusive organization of major turbomachinery developers and users who have united with the

Turbo Lab to find answers to important questions about turbomachinery performance and reliability through cutting-edge research. Approximately 40 industrial and government organizations provide annual grants of \$25,000 to support a broad range of member-selected research projects.

TRC members have access to XLTRC², a suite of high-speed, experimentally verified and user-friendly codes for executing a complete lateral and torsional rotordynamic analysis of rotating machinery, including pumps, compressors and turbines. XLTRC² is bundled with 25 or more examples of rotordynamic analysis, including rotors for compressors, pumps and gas turbines. Each model features distinctive bearing/seal support conditions and displays unique characteristics of rotordynamic behavior.

XLTRC² runs on Vista and Win7 and Microsoft Excel, 2007 and 2010. Extensive help files are provided for the base and support-library codes. SI or

US units can be used interchangeably.

In addition to funding from the TRC, the Turbo Lab receives funding from grants and contracts from government agencies, the State of Texas and private companies. Funds provide continuing support for graduate research and education related to performance, rotordynamics, acoustics, seals, tribology, couplings, computational and experimental fluid dynamics, heat transfer, torsional vibrations, materials and finite element analysis.

For more information on TRC
or XLTRC², visit
turbolab.tamu.edu/trc.

UNDERGRADUATE & GRADUATE EDUCATION

The Turbo Lab draws on the world-renowned research expertise of Texas A&M University's Dwight Look College of Engineering and the Texas A&M Engineering Experiment Station to provide undergraduate and graduate education programs that develop highly skilled, industry-ready engineers.

UNDERGRADUATE

Students are provided elective options in turbomachinery performance, fluid and thermal science, vibrations, stress analysis and related topics.

In addition, qualified undergraduate students work at the Lab under funded research projects or course credit, and the Lab supports Research Experiences for Undergraduates (REU) opportunities in conjunction with the National Science Foundation.

GRADUATE

Graduate students in the Turbo Lab are remarkably well-prepared to step into leading positions within the turbomachinery industry, government research laboratories, and academia. The Lab's balance between empirical validation of prediction and fundamental scientific research sets the program apart from related graduate coursework elsewhere. Students are provided general performance, reliability, and fundamental research projects in conjunction with specific classroom electives in turbomachinery, rotordynamics, heat transfer, and aerothermodynamics, among others.

DID YOU KNOW?

The Turbo Lab offers extended short courses throughout the year in Houston, TX and Southeast Asia.

turbolab.tamu.edu/short-courses



OUR FACULTY



DR. ERIC PETERSEN is the director of the Turbomachinery Laboratory. Petersen has been with the Turbo Lab for more than 10 years, and is the Nelson-Jackson Professor in the Department of Mechanical Engineering. His research encompasses gas dynamics, propulsion, combustion, shock waves, chemical kinetics, optical diagnostics and spectroscopy, laminar and turbulent flames, and rocket combustion. He has authored more than 400 journal and conference papers in these areas. He is vice-president of the Institute for Dynamics of Explosions and Reactive Systems (IDERS) and an associate editor of the Journal of Engineering for Gas Turbines and Power and the Journal of Propulsion and Power. He is a fellow of the American Society of Mechanical Engineers (ASME) and a member of the American Institute of Aeronautics and Astronautics (AIAA), The Combustion Institute and the American Society for Engineering Education (ASEE).



DR. PAUL CIZMAS is a professor of aerospace engineering. Before joining Texas A&M, he worked for Westinghouse Science and Technology Center in Pittsburgh, Pa. While at Westinghouse, Cizmas was responsible for the development of computational fluid dynamic analysis for turbomachinery. At Texas A&M his work concentrates on simulation of unsteady flows in turbomachinery, combustion, aeroelasticity and rotordynamics. He developed several flow simulation codes that are currently licensed to the major turbomachinery companies. He received the ASME Liquid Propulsion Best Paper Award for his work on time linearization and the ASME Structures & Dynamics Committee Best Paper Award for his work on the prediction of aeroacoustic resonance in cavities of hole-pattern stator seals. He is an ASME Fellow and Associate Fellow of AIAA. Visit dayton.tamu.edu for more on his research.

OUR FACULTY continued



DR. ADOLFO DELGADO is an associate professor of mechanical engineering. His research focuses on rotordynamics, structural vibration, energy dissipation mechanisms, thin film lubrication and fluid-structure interaction applied to the design, modeling and improvement of rotating machinery systems and components. Prior to joining Texas A&M, Delgado was a research engineer at the General Electric Global Research Center where he led and worked on multiple initiatives involving improvement of existing rotating equipment and development of new rotor-bearing system architectures and turbomachinery components, such as variable geometry bearings, annular seals, dampers and oil-free bearings.

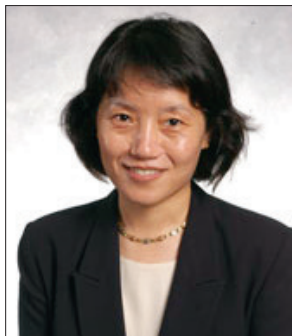


DR. JE-CHIN HAN is a Distinguished Professor and Marcus Easterling Endowed Chair Professor. Han received his bachelor's degree from National Taiwan University, a master's degree from Lehigh University and a Sc.D. degree from M.I.T., all in mechanical engineering. He has worked on gas turbine heat transfer and cooling research for over 40 years. He is the co-author of more than 220 refereed journal papers. He received the 2002 American Society of Mechanical Engineers (ASME) Heat Transfer Memorial Award, 2004 International Rotating Machinery Award, 2004 American Institute of Aeronautics and Astronautics (AIAA) Thermophysics Award 2016 ASME International Gas Turbine Institute (IGTI) Aircraft Engine Technology Award and 2016 ASME/AIChE Max Jakob Memorial Award. Han is an ASME and AIAA fellow and has served as an editor or an associate editor for eight heat transfer-related journals.

OUR FACULTY continued



DR. WARUNA KULATILAKA is an associate professor of mechanical engineering. His research interests are advanced optical and laser-based diagnostics for gas turbine combustion and propulsion applications, as well as reacting and non-reacting flow studies. He has published nearly 50 peer-reviewed journal articles in these areas. Prior to joining Texas A&M, he was a senior research scientist and contractor at the Air Force Research Laboratory (AFRL-WPAFB), and completed a postdoctoral term at the Combustion Research Facility at Sandia National Laboratories, CA. Kulatilaka is active in numerous professional organizations, including ASME (fellow), AIAA (associate fellow), OSA (senior member), The Combustion Institute (board member–CSS), APS and American Society for Engineering Education (ASEE). He has received several awards for outstanding technical contributions and service.



DR. HONG LIANG is a professor of mechanical engineering. She has long-lasting interests in design, synthesis and evaluation of highly lubricious and wear-resistant advanced materials, coatings, and novel surface structures. Liang and her research group's fundamental understanding and innovative approaches help to improve performance and efficiency, reduce energy waste, and extend service life of mechanical systems and/or components. Liang is a fellow of ASME and the Society of Tribologist and Lubrication Engineers (STLE). She is the editor of Tribology International.

The professional staff, engineering faculty members, and more than 80 graduate students of the Laboratory represent a balance of experimental, computational, and analytical expertise in applied and fundamental research for turbomachinery, propulsion, and energy applications.

OUR FACULTY continued



DR. ALAN PALAZZOLO is the James J. Cain I Professor of Mechanical Engineering and has industrial and govt. lab experience at Bently Nevada Corp., Allis Chalmers, Southwest Research Institute, NASA Glenn and NASA Marshall Spaceflight Centers. He performed over \$10 million in pro-rated funded research for NASA, ARL, DOE, ONR, the government of Qatar and many private companies. He is an ASME fellow, Endowed Professor, R&D 100 Award recipient, author of over 80 archival journal publications, holder of 3 U.S. patents, author of the textbook, “Vibration Theory and Applications,” and recipient of the best paper of the year award for the ASME Journal of Tribology for 2014 and 2016. He has chaired 47 completed MS students and 29 PhD students. Approximately 100 undergrad students have worked in his lab as lab assistants. His research specialties include rotordynamics, drill string vibration, magnetic bearings, energy storage flywheels, desalination centrifuges, heart pumps, CFD for turbomachinery, fluid film bearings and seals, gears and couplings. Visit vcel.tamu.edu for more on Dr. Palazzolo’s research.



DR. ANDREAS POLYCARPOU is the James J. Cain Chair, Kotzebue ’14 Professor, and head of the Department of Mechanical Engineering. His research expertise lies in tribology and coatings for extreme operating conditions. Before joining Texas A&M in 2012, he was a faculty member at the University of Illinois at Urbana-Champaign. Polycarpou has studied friction, wear and scuffing issues under extreme operating conditions including high temperature, starved lubrication and high pressures. Application areas for his research include air-conditioning and refrigeration compressors, nuclear reactors, automotive, electrical submersible pumps, valves and other oil and gas-related devices. Polycarpou is the author of 200 archival journal papers, numerous book chapters, volume proceedings, patents and conference papers. Polycarpou has won several national and international awards, including honors from the American Society of Mechanical Engineers and the Society of Tribologists and Lubrication Engineering. He is a fellow of both societies.

OUR FACULTY continued



DR. LUIS SAN ANDRÉS is the Mast-Childs Chair Professor of Mechanical Engineering at Texas A&M University. At the Turbomachinery Laboratory, San Andrés conducts engineering research, theoretical and experimental on fluid film bearings and seals for high performance turbomachinery, gas foil bearings for high temperature oil-free turbomachinery, hybrid fluid film bearings for cryogenic turbopumps, rotor-bearing systems for turbochargers, and squeeze film dampers for aircraft jet engines. His computational codes, benchmarked against test data, are standards in the rotating machinery industry. San Andrés and students have authored over 170 journal papers and 80 conference papers, several having earned Best Paper awards. San Andrés, a fellow of ASME and STLE, is an Advisory Member for the TEES Turbomachinery and Pump Symposia in Houston, Singapore and Doha, as well as the Global Power and Propulsion Society based in Zurich. Visit his research URL at rotorlab.tamu.edu.

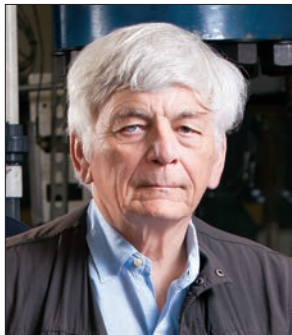


DR. LESLEY WRIGHT is an Associate Professor of Mechanical Engineering. Prior to joining Texas A&M, she was a member of the Mechanical Engineering faculty at Baylor University for ten years. She returns to Texas A&M where she earned her Ph.D. in Mechanical Engineering in 2006. Currently she is investigating enhanced convective cooling technology, including heat transfer enhancement for gas turbine cooling applications. This experimental research has led to the development of innovative cooling technology for both turbine blade film cooling and internal heat transfer enhancement. In addition, Dr. Wright continues to investigate the effect of rotation on the thermal performance of rotor blade cooling passages. Her research interests have also led to the development of novel experimental methods for the acquisition of detailed surface and flow measurements in highly turbulent flows.

OUR EMERITUS FACULTY



DR. GERALD MORRISON retired from his post as professor of mechanical engineering in 2017. He has worked in the areas of fluid mechanics, metrology, and turbulence since 1973. Morrison has guided experimental studies on flow inside seals used on pumps, compressors, and turbines using laser and thermal anemometry to measure the flows inside these items. Extensive experimental and computational work on obstruction flow meters resulted in several patents being issued for a new type of flow meter useful in multi-phase flows. He has performed leading research on 3-D laser Doppler anemometry and Doppler global anemometry and their use in turbomachines. Turbulence measurement and analysis using advanced signal analysis techniques are an area of his expertise. Devices used for measurement include pressure probes, thermal anemometry, and laser anemometry systems.



DR. DARA CHILDS was Director of the Turbomachinery Laboratory from 1984 until he retired in 2018. He held the Leland T. Jordan Chair in Mechanical Engineering. Before joining Texas A&M, he taught at The University of Louisville and Colorado State University. He began his professional career at Rocketdyne working on the F1 and J2 engines for the Apollo program. He worked actively to resolve problems in the high-pressure turbopumps of the space shuttle main engine. He has continued to work steadily for over 50 years on rotordynamic issues related to rocket-engine turbopumps and commercial turbomachinery. He has authored or co-authored numerous journal papers on rotordynamics, plus the heavily-cited 1993 book, “Turbomachinery Rotordynamics: Phenomena, Modeling and Analysis.” His most recent book, “Turbomachinery Rotordynamics with Case Studies,” was released in June 2014.

Texas A&M University has attracted outstanding engineering faculty with broad industrial experience to support turbomachinery-related research and education.



Continuing education opportunities are paramount for industry professionals to sharpen their skills and remain abreast of the latest developments and technology in the industry. Built on a history of success, Turbo Lab-sponsored continuing education and professional development opportunities are highly regarded across the world.



CONTINUING EDUCATION & PROFESSIONAL DEVELOPMENT

TURBOMACHINERY & PUMP SYMPOSIA

From a modest beginning on the campus of Texas A&M University in 1972, the Turbomachinery & International Pump Users Symposia (TPS) has become the principle meeting for users and manufacturers of industrial turbomachinery.

Held annually in Houston, Texas, TPS was established to promote professional development, technology transfer, peer networking and information exchange among industry professionals. TPS features a world-class technical program presented by engineers and selected by an advisory committee of industry experts, combined with an international exhibition of more than 350 companies. TPS is consistently regarded as the premiere event for turbomachinery and pump professionals.

To view the full program, the list of exhibiting companies or register for our next symposia, visit tps.tamu.edu.

ASIA TURBOMACHINERY & PUMP SYMPOSIUM

Much like TPS, the Asia Turbomachinery & Pump Symposium (ATPS) began as an assembly for turbomachinery and pump users and manufacturers. ATPS, held biennially in Southeast Asia, offers a world-class educational forum and international exhibition for working engineers in both the turbomachinery and pump industries.

For more information, visit atps.tamu.edu.

MIDDLE EAST TURBOMACHINERY SYMPOSIUM

The Turbomachinery Laboratory hosted the Middle East Turbomachinery Symposium (METS) in Qatar in 2011, 2013 and 2015. The conference was established with underwriting support from Qatar Petroleum and in response to the rapid development of the natural gas industry in the State of Qatar.



CONTINUING EDUCATION & PROFESSIONAL DEVELOPMENT continued

All proceedings from previous symposia are available at turbolab.tamu.edu/proceedings.

PROCEEDINGS

Papers presented at the symposia are solicited and reviewed by advisory committee members from leading companies, including users, OEMs, service providers, researchers and consultants. The enduring value of these papers is confirmed by practicing engineers who repeatedly reference and cite their contents.

SHORT COURSES

Extended short courses offered throughout the year are developed and presented by leading engineers in several locations, including the US and Southeast Asia. Topics evolve to meet the needs of working professionals in the turbomachinery industry.

Experts interested in developing and presenting courses are invited

to submit proposals to ml-publications@turbolab.tamu.edu. For more information on extended short courses, visit turbolab.tamu.edu/proceedings.

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EVENT INFORMATION

TURBOMACHINERY & PUMP SYMPOSIA

When: Annually in September

Where: George R. Brown Convention
Center, Houston, TX

Web: tps.tamu.edu

ASIA TURBOMACHINERY & PUMP SYMPOSIUM

When: Biennially in the Spring
(even years)

Where: Southeast Asia

Web: atps.tamu.edu

EXTENDED SHORT COURSES

When: Varied throughout the year

Where: Houston, Texas; Southeast Asia

Web: turbolab.tamu.edu/short-courses



JOIN TRC TODAY

The Turbomachinery Research Consortium (TRC) is an exclusive organization of major turbomachinery developers and users who have united with the Turbo Lab to find answers to important questions about turbomachinery performance and reliability through cutting-edge research.

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Debbie Maggs, Program Coordinator
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