

GAS TURBINE LABORATORY

Gas turbine engines are of central importance to the global transportation and energy generation network. With applications for aircraft propulsion (jet engines), power generation and many other purposes, improvements in the efficiency, reliability or emissions of these engines can have far-reaching impacts. The Ohio State University Gas Turbine Laboratory (GTL) seeks to combine the best aspects of academic and industrial research to advance the state-of-the-art in gas turbine optimization and design. Research projects improve the efficiency, reliability and emissions of these engines while also providing students with an opportunity to develop in-depth knowledge of turbomachinery systems and analysis tools.

Current GTL research focuses include:

- Heat transfer and aerodynamic programs taking measurements and making predictions for cooled full-scale turbines operating at corrected conditions and for flow inside the blade internal cooling passages
- Aeromechanics research programs investigating the effect of engine-speed blade tip rub events as well as a variety of damping and mistuning studies
- Structural dynamics research including the modeling of UAV ingestions into engines, creation of new reduced order modeling methods for turbomachinery, and new nonlinear dynamic analysis for friction and cracks

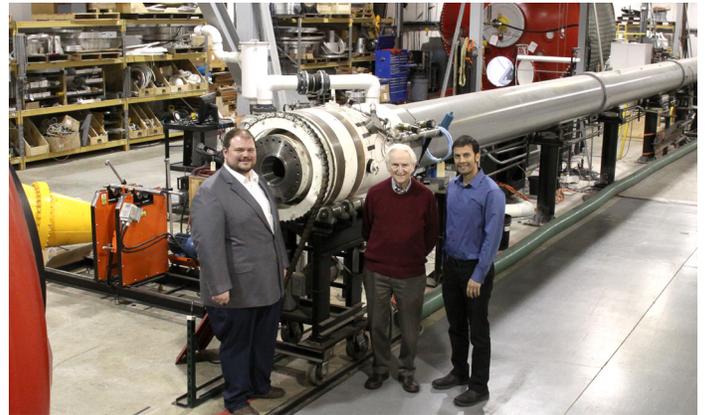
Research projects are performed in close collaboration with industrial partners to ensure that the results are representative of engine conditions and relevant to current design questions.

GTL FACILITIES

The GTL has several state-of-the-art research facilities used to study the aerodynamics, heat transfer, aeromechanics and structural dynamics of turbomachinery, including:

Turbine Test Facility (TTF)

The TTF is designed to replicate the corrected mass flow, corrected speed, pressure ratio and temperature ratios for a full-scale high-pressure turbine. It consists of a 100-foot-long shock tunnel attached to a 32-foot-long by 9-foot-diameter dump tank in which the turbine rig is mounted. These rigs are built using real engine hardware and are heavily instrumented. High-speed data is collected from rakes, fixed shrouds and stators, and rotating blades to characterize the unsteady effects that are a critical part of any engine's operation. In addition to heat transfer and aerodynamics studies, the facility can be used for performance measurements and to investigate forced response issues.



Compressor Spin Pit Facility (CSPF)

The CSPF consists of an in-ground containment tank that supports a highly rigid spindle rated at 20,000 rpm and can accommodate medium to large compressor and turbine rotors (maximum diameter 34-inches). The CSPF is intended to generate the data needed to validate emerging modeling and design tools for the development of aircraft gas turbine engines. The facility has been used to study blade-casing rub-in-systems of the type used on contemporary gas turbines to improve the tip clearance behavior for the engine's entire life span as well as in damping/mistuning studies.

Large Spin Pit Facility (LSPF)

The LSPF's primary purpose is to study the physics of blade tip-rubs and other aeromechanic events. Compared to the CSPF, distinctive features of the LSPF are a progressive incursion mechanism that allows control of the incursion rate and depth instead of just depth and optical access windows for high-speed imaging of the rub event. The LSPF is also large enough to accommodate bladed rotors up to 60 inches in diameter. In addition to continuing aeromechanics research, this facility can also be used for internal heat transfer experiments investigating the flow through large-scale blade internal cooling passages using liquid crystal thermography or heated copper panel techniques.

Large Fan Spin Tank (LFST)

The newest facility at the Gas Turbine Laboratory is the LFST. This facility has an inside diameter of 172 inches and can hold a bladed disk 14 feet in diameter. Like the underground spin tanks, this facility was developed for aeromechanics and structural dynamics research. In particular, the initial programs that will be run in this facility are blade damping, mistuning and excitation studies.





High Speed Signal Processing and Data Acquisition Systems:

These facilities are supported by a range of data acquisition systems that provide over 750 channels of high-speed, high-accuracy measurements along with an additional 300+ channels of low speed facility measurements. Each system has associated preamplifiers that provide high bandwidth (3-MHz) and low noise signal conditioning. Small scale and ruggedized versions of these signal conditioners can be embedded onboard rotating hardware to improve signal quality from instruments that are routed through slip rings.

Light Probes

The laboratory uses an Agilis 8-probe measurement system with the Agilis c360 Vibration Intelligence Software for measuring blade arrival times and therefore blade deflection amplitudes (referred to as Tip Timing). The Agilis c360 Real Time Software has the capability to display data real-time as well as write and store data files for further analysis by the c360 Off Line Software.

Infrared cameras

The laboratory utilizes two infrared cameras including a high-speed FLIR x6900sc LWIR model with a minimum integration time of 270 nanoseconds. These cameras can be used for transient heat transfer measurements and the study of friction heating in dampers or blade tip rub events.

Ohio State's GTL is a Pratt & Whitney Center of Excellence for blade tip rubs. The center's activities focus on upgrading the current LSPF facility to enable the investigation of blade tip rubs at elevated temperatures similar to those seen in a compressor. Moreover, a new high temperature blade tip rub facility that can operate at temperatures seen in the turbine is being developed.

GOALS OF THE GTL

Research

Conducting research that addresses scientific and technological challenges related to turbomachinery that affects the State of Ohio, the nation, and the world through collaborations within the College of Engineering and with industry and government agencies.

Education

Provide a world class undergraduate and graduate education to students in the classroom and in the research lab.

- Produce well-qualified graduate students and postdoctoral scholars with significant academic (conference and journal publications) and industrial (sponsored programs, real world context) experiences who will be future leaders in industry, government and academia.
- Offer undergraduate research opportunities (research projects, paid internships, undergraduate theses) to students that provide research and industrial experience they cannot attain in the classroom alone.

Personnel

Develop a diverse and inclusive research group that includes specially trained staff who are experts in rotating machinery and students (ranging from undergraduate to graduate) with appropriate redundancies in key areas to ensure the ability to meet project deadlines.

Facilities

Continue to transform our facilities and instrumentation to drive learning and innovation.

HISTORY OF THE GTL

After 35 years in industry, Mike Dunn joined with one of his co-workers, Reza Abhari, and moved to Columbus in late 1995, bringing with them the GTL that the group had been developing at Cornell Aeronautical Laboratory (which later became Calspan) since 1976. They were accompanied by three non-faculty researchers who were an essential part of the team in Buffalo. From its inception the GTL has had a strong tie to a variety of industry sponsors, working closely with them to design and run experiments.

In 2013, Randy Mathison became an assistant professor in the Department of Mechanical and Aerospace Engineering after 12 years of experience in the laboratory as a graduate student and then research engineer. Mathison's strengths are in design and experimentation with a focus on the heat transfer and aerodynamics of gas turbines. The next year Kiran D'Souza was hired as an assistant professor to complement the lab's strengths with a background in computational modelling and structural dynamics. The two faculty members assumed day-to-day operations of the GTL in 2017, when Mike Dunn became a professor emeritus. All three faculty work closely on ongoing projects at the GTL, while also bringing in new programs.

CONTACT

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