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IN THIS ISSUE...

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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ASME GLOBAL GAS TURBINE NEWS (GGTN)

Letter from the Editorial Committee

DEAR READERS,

As we reflect on the success of ASME Turbo Expo 2026 in Milan, we want to celebrate a record level of participation from researchers, industry leaders, students, and practitioners from around the world, reaffirming the vitality, innovation, and collaborative spirit that continues to drive our field forward. The exchange of ideas witnessed throughout the week highlighted not only the technical excellence of our community but also its commitment to addressing the evolving challenges of power generation, propulsion, and sustainability. The two articles of this issue showcase how innovation is expanding both the analytical capabilities and the operational safety of modern gas turbine systems.

In our first article, researchers from the University of Melbourne present pioneering work on the use of exascale supercomputing to quantify the impact of surface roughness on turbine aerothermal performance, revealing how small changes in surface condition can significantly influence heat transfer, aerodynamic losses, and component performances. The second article from Baker Hughes explores the application of Ultrasonic Gas Leak Detectors (UGLDs) for flexible-fuel gas turbines operating with natural gas, hydrogen, and blended fuels. As the energy transition accelerates the adoption of low-carbon fuels, ensuring safe operation becomes increasingly critical: innovative sensing technologies can help enable fuel flexibility and hydrogen deployment without compromising safety and availability.

This edition also marks an important transition for the Global Gas Turbine News Editorial Committee. After launching this editorial series and guiding GGTN with dedication, insight, and enthusiasm, **Dr. Tamy Guimarães** is passing the baton to **Dr. Angela Serra** as editorial lead. This transition reflects the strength of our community's collaboration across industry and academia: a partnership that has always been central to innovation in turbomachinery. As we move forward, our commitment remains unchanged: to provide a platform that connects perspectives, shares emerging knowledge, and fosters the cross-disciplinary exchange that transforms challenges into new opportunities for innovation, With special thanks to Dr. Tamy Guimarães for her leadership and contributions to GGTN.

Warm regards,

DR. ANGELA SERRA
On behalf of the Editorial Committee
ASME Global Gas Turbine News

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From Supercomputing to Service Life: Quantifying the Impact of Surface Roughness on Turbine Aerothermal Performance

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THE PROBLEM

Gas turbine (GT) components operate in harsh environments that lead to their progressive degradation through mechanisms such as ablation, erosion and fouling. These mechanisms increase the levels of surface roughness which can significantly impair aero-thermal performance (heat transfer and drag) over time. In fact, empirical correlations demonstrate that even moderate levels of in-service degradation can reduce stage efficiency by as much as 8% in high pressure turbines (HPTs), while increasing convective heat transfer to the metal [1]. In-service roughness is therefore widely recognised as a major contributor to efficiency losses, increased fuel consumption, and increased maintenance requirements throughout engine service life. Incorporating accurate models of roughness-induced penalties into predictive frameworks is therefore essential for reliable efficiency estimation and the development of robust next-generation turbines.

THE CHALLENGE

The fundamental difficulty in accurately predicting roughness effects on aerothermal performance arises from the vast separation of length scales involved: a typical HPT vane in a modern aero-engine may have a chord length of up to ten centimetres, whereas the relevant roughness features are often only tens of micrometres in height - comparable to the width of a human hair. In power-generation gas turbines, vane chord lengths are often even much larger, further increasing the disparity in scales.

An additional complication is that roughness can exist in an effectively infinite range of surface topographies, including variations in height, spacing, shape, distribution, and orientation [2]. Consequently, no universal “one-size-fits-all” model exists for predicting its influence on heat transfer and / or aerodynamic drag. Different roughness topographies can produce markedly different flow responses, even when conventional industry metrics, such as mean absolute roughness height, are similar [3]. Surface roughness must therefore be regarded as an inherently multi-scale and multi-dimensional problem in turbine research, and its effects cannot be neglected in the development of reliable aero-thermal performance models. Indeed, the geometric complexity introduced by roughness has been identified as one of the key challenges in NASA’s Vision 2030 Aircraft Propulsion Grand Challenge Problems [4].

It is well established that lower-order modelling approaches, such as Reynolds-Averaged Navier–Stokes (RANS) approaches, lack the fidelity required to accurately capture the complex flow physics associated with realistic rough surfaces in high-pressure turbines. Consequently, higher-fidelity scale-resolving simulation approaches are required to resolve the detailed flow structures and aero-thermal interactions responsible for roughness-induced performance degradation. However, such simulations are computationally demanding, often requiring billions of grid points to resolve the full spectrum of hydrodynamic, thermodynamic and topographical scales that dictate aero-thermal performance prediction. Until recently, these extreme computational requirements limited the routine application of high-fidelity methods to realistic HPT configurations.

THE BREAKTHROUGH

The emergence of exascale computing has transformed what types of problems can be tackled. Leveraging the tremendous computing resources offered by modern GPU (Graphics Processing Unit) accelerated supercomputing architectures, researchers at the University of Melbourne have performed the first Direct Numerical Simulations (DNS) of flow over HPT vanes with realistic non-Gaussian micron-scale surface roughness in collaboration with GE Aerospace [5]. To ensure strong industrial relevance, these simulations incorporated target operating conditions and surface roughness distributions based on data from in-service HPT airfoils. The pioneering simulations were enabled by the speed and scalability of Melbourne University's in-house GPU-accelerated flow solver HIPSTAR, or High-Performance Solver for Turbulence and Aeroacoustic Research, which is a cutting-edge computational fluid dynamics and simulation software developed by Prof. Richard Sandberg. His research team, combined with the flexibility of in-house surface generation algorithms [6] and purpose-built post-processing libraries are capable of analysing hundreds of terabytes of simulation data within seconds. Collectively, these capabilities have enabled routine simulations of HPT vanes at engine-relevant Mach and Reynolds numbers for user-specified roughness topographies.

A representative simulation snapshot is shown in Figure 1, comparing suction-side boundary layer development for smooth and rough turbine vanes. Vortical structures, identified using the Q-criterion, a vortex identification method based on the invariants of the velocity gradient tensor, reveal striking differences between the two cases. The smooth vane exhibits negligible vortical activity along the suction surface before undergoing bypass transition to turbulence near the trailing edge (see inset showing the footprint of intermittent turbulent spots). In contrast, the rough vane undergoes rapid laminar-to-turbulent transition almost immediately downstream of the leading edge and remains turbulent thereafter. The earlier roughness-induced transition enhances near-wall mixing and heat transfer, generating

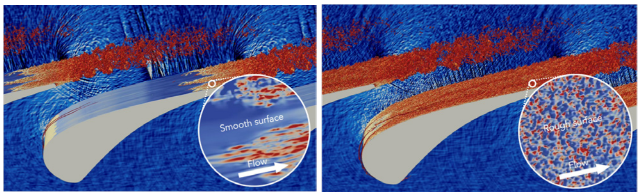

Figure 1 – Suction-side transition mechanisms for a high-pressure turbine vane with (top) smooth and (bottom) rough surfaces. Three-dimensional vortical structures are identified using the Q-criterion, while the background contours represent the divergence of the velocity field. Insets provide magnified views of the viscous shear stress on the blade surface.

a more energetic wake that is shed downstream and ultimately also influences the aerodynamic and thermal performance of downstream blade rows.

The integrated effect of the instantaneous flow differences shown in Figure 1 is quantified in Figure 2-Left , which presents the pitch-integrated kinematic wake loss for four rough vane configurations with systematically varied leading-edge roughness, alongside a smooth reference vane for comparison. Relative to the smooth case, all rough configurations exhibit substantially higher aerodynamic losses, with the vane containing the most pronounced leading-edge roughness features showing an increase in wake loss of approximately 40%.

Crucially, the resulting DNS database has provided researchers at the University of Melbourne with a unique opportunity to rigorously evaluate the validity of long-established surface roughness models originally calibrated using canonical flow configurations, such as flat-plate zero-pressure-gradient boundary layers. The findings show that the de facto standard methodology for modelling surface roughness - namely, the determination of an equivalent value of Nikuradse's sandgrain roughness [7] - is not universally transferable to HPT environments. This limitation stems from the fact that the assumptions underpinning such models, including high-Reynolds-number flow and spatially uniform roughness distributions, are often violated under engine-relevant turbine operating conditions and on realistic vane surfaces. The data were also used to evaluate whether surface roughness increases both heat transfer and aerodynamic drag on the blade surface in equal proportion. For turbulent flow over smooth walls, these quantities are often assumed to scale together through Reynolds' analogy. However, over certain rough surfaces, heat transfer enhancements can occur alongside disproportionately larger increases in drag. This behaviour is illustrated in Figure 2-right, which compares the rough-to-smooth ratio of Nusselt number with the corresponding skin-friction drag integrated over the vane suction surface. Most cases broadly follow Reynolds' analogy (diagonal dashed line), while two configurations show a clear departure from this trend, corresponding to cases that undergo rapid roughness-induced transition to turbulence along the suction surface.

Collectively, these results underscore the critical role of surface

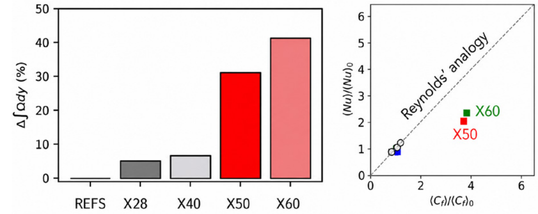

Figure 2 – Impact of surface roughness on (left) pitch-integrated loss, expressed as the percentage increase relative to the reference smooth vane (REFS), and (right) Reynolds analogy plot showing the ratio of rough-to-smooth Nusselt number as a function of the ratio of rough-to-smooth skin friction. The different cases simulated have rough suction sides up to 28% - 60% axial chord, denoted by X28-X60, respectively. Results from [5].

roughness in governing transition mechanisms and the associated aerodynamic penalty. More broadly, they illustrate how relatively small variations in surface condition can fundamentally alter boundary-layer development, heat transfer and wake characteristics.

THE FUTURE

While DNS of HPT vanes with micron-scale surface roughness is now possible, much work remains to be done, and the current simulations should be viewed as a first step towards a more complete understanding of real engine flows. Chief among the outstanding challenges is the interaction between surface roughness and film-cooling, where coolant jets issued from discrete holes interact with highly irregular near-wall turbulence, potentially altering both cooling effectiveness and local heat transfer in ways that are not yet fully understood.

Furthermore, the impact of end-walls in realistic annular configurations introduces additional layers of complexity, as secondary flows such as passage vortices and corner separations significantly modify near-wall transport and can strongly interact with both surface roughness and film-cooling effectiveness. These effects are further compounded by the combined influence of high free-stream turbulence, incoming wakes, strong adverse pressure gradients, and three-dimensional separation, all of which complicate the boundary-layer development and loss mechanisms in high-pressure turbines, particularly in engine-relevant Reynolds-number regimes.

Continued progress in computational capability will allow researchers to also include these effects. At the same time, it will be crucial to employ innovative techniques to translate the vast data sets to accurate lower-order models suitable for rapid design iterations.

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Application of Ultrasonic Gas Leak Detection for Flexible-Fuel Gas Turbines in Energy Transition Scenarios

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The ongoing energy transition is driving gas turbine technology toward increasing flexibility in fuel composition, spanning from conventional natural gas to hydrogen and intermediate blends. This evolution introduces new safety challenges, primarily due to the different physical and chemical properties of the fuels involved. In particular, hydrogen exhibits a wider flammability range, lower ignition energy, and higher reactivity, requiring fast and reliable gas detection systems within gas turbine packages.
Gas turbines are typically installed inside acoustic enclosures containing high-temperature components and complex fuel gas systems, where multiple potential leakage points exist. In such environments, gas detection system plays a fundamental role in preventing hazardous events by triggering timely mitigation actions. This work investigates the application of Ultrasonic Gas Leak Detectors (UGLDs) to support safe operation of gas turbine packages operating with flexible fuel compositions. Experimental tests were conducted in a real gas turbine enclosure under different operating conditions, using helium as a surrogate for hydrogen. Additional tests were performed to evaluate the capability of ultrasonic technology to differentiate between different gas leak types.

GAS TURBINES IN ENERGY TRANSITION

The decarbonization of power generation is accelerating the adoption of alternative fuels in gas turbines, with hydrogen playing a central role in reducing CO_2 emissions. However, current and future market requirements rarely involve a direct transition from 100% natural gas to 100% hydrogen. Indeed, gas turbines are increasingly expected to operate across a wide range of fuel blends, enabling gradual transition pathways and operational flexibility: this introduces significant complexity in system design and operation. Gas properties can vary considerably depending on the blending ratio, affecting combustion behavior, material compatibility and critically safety management strategies.

From a safety perspective, hydrogen represents a step change compared to natural gas. Its low ignition energy and high flame speed increase the likelihood and severity of potential ignition events. When leaks occur inside gas turbine enclosures, the coexistence of flammable mixtures and hot surfaces creates a high-risk scenario that must be mitigated through a combination of ventilation and detection systems.

Therefore, enabling fuel flexibility requires not only combustion and material adaptations, but also advanced gas detection systems capable of handling multiple gases and mixtures under varying operating conditions.

THE ROLE OF GAS DETECTION IN ENCLOSED ENVIRONMENTS

In conventional gas turbine applications, gas detection systems are primarily designed for natural gas. However, as fuel composition evolves toward hydrogen and blends, traditional technologies show limitations. Infrared detectors (IR), widely adopted in gas turbines, cannot detect hydrogen, while catalytic sensors have relatively slow response times and require continuous maintenance.

Table 1. Technical features comparison between different technologies of gas detectors.

	Catalytic	IR	Ultrasonic	Thermal Conductivity Detector
Response Time	< 13 s	< 8 s	< 2 s	< 1 s
H_2 detection	Yes	No	Yes	Yes
Accuracy	High	High	High	Low
Calibration Required	Yes	No	No	No
Contact with leak	Yes	Yes	No	Yes
Cost	Low	Low	High	Low

These limitations become critical in flexible-fuel scenarios where:

- the composition of the fuel gas may vary over time
- mixtures may contain significant hydrogen fractions
- fast detection becomes essential to prevent rapid ignition

In this context, detection systems must evolve from gas-specific concentration measurement towards having the fast response and fuel-independent leak detection principles. Ultrasonic gas leak detection meets these requirements by focusing on the physical phenomenon of the leak rate rather than the gas type. High-pressure leaks generate ultrasonic emissions due to under-expanded sonic jets, which can be detected almost instantaneously, regardless of gas composition [1].

ULTRASONIC DETECTION AS AN ENABLING TECHNOLOGY FOR FUEL FLEXIBILITY

A key advantage of UGLDs is their capability to respond to any pressurized gas leak. This characteristic is particularly relevant for gas turbine OEMs and operators, who must ensure safe operation across different fuels without redesigning the detection architecture.

Moreover, experimental results indicate that ultrasonic signals differ depending on the gas properties. Tests performed using helium and nitrogen show that lighter gases (like helium used as hydrogen surrogate) generate higher sound pressure levels in the ultrasonic range compared to heavier gases. This behavior opens the possibility of distinguishing between hazardous fuel leaks and non-critical air leaks, which is highly valuable in reducing unnecessary trips and improving operational availability.

SAFETY-CRITICAL ASPECTS AND DETECTION PERFORMANCE

Safety remains the primary driver behind the adoption of advanced gas detection technologies. In gas turbine enclosures, two main leak scenarios are identified:

- Minor leaks, where ventilation can dilute the gas below flammable limits.
- Major leaks, where rapid accumulation may lead to hazardous conditions.

In the second case, the response time of the detection system is the critical parameter, as it directly affects the duration of exposure to a flammable mixture. Ultrasonic detectors provide response times in the order of 1–2 seconds, significantly faster than conventional technologies described in Table 1.
Experimental campaigns conducted in real gas turbine enclosures demonstrate that [2]:

- leaks can be detected even under full-speed, full-load conditions
- background noise does not generate spurious alarms when properly filtered
- detection sensitivity is influenced by sensor placement and distance from leak source

While small leaks may require optimized positioning strategies, large leaks are reliably detected across the enclosure, confirming the robustness of the technology even in highly noisy environments.

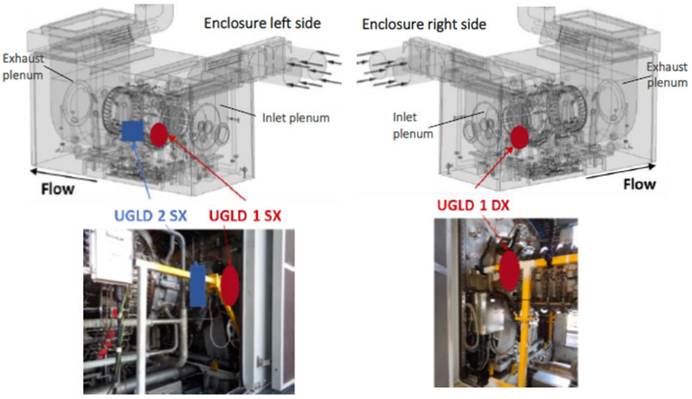

Figure 1. Ultrasound Gas Leak Detectors position inside GT enclosure [1].

IMPLICATIONS FOR GAS TURBINE DESIGN

The adoption of ultrasonic gas detection has important implications for future gas turbine design in energy transition scenarios:

1. Fuel-agnostic safety systems. A single detection technology can support multiple fuels and blends without reconfiguration.
2. Reduced response time. Faster detection reduces risk exposure and supports safe operation with hydrogen.
3. Improved availability. The ability to differentiate between gas types and avoid unecessary shutdowns can enhance plant reliability and availability.
4. Simplified integration. Non-contact detection allows flexible sensor placement in complex and harsh environments.

Overall, ultrasonic detection can be considered an enabling technology for the safe deployment of flexible-fuel gas turbines, supporting both decarbonization goals and operational requirements.

CONCLUSIONS

The transition from natural gas to hydrogen and blended fuels requires a paradigm shift in gas turbine safety systems. Traditional detection technologies are not fully adequate to address the challenges posed by fuel flexibility and hydrogen reactivity.
Ultrasonic gas leak detection offers a promising solution by combining:

- very fast response time
- independence from gas type
- robustness in noisy and confined environments

The experimental results confirm that UGLDs can effectively detect hydrogen leaks and provide additional advantages in distinguishing between different gas types. These capabilities make ultrasonic detection a key enabler for the safe operation of next-generation gas turbine packages in energy transition scenarios.

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2026 TURBO EXPO

Wrap Up

ASME Turbo Expo 2026, in Milan, Italy maintained its reputation as the world's premier turbomachinery conference with over 3000 professionals. Throughout the week, delegates shared practical experiences, knowledge, and ideas on the latest turbine technology trends through networking opportunities and over 2000 peer-reviewed technical presentations.

This year's three-day exhibition brought together more than 150 exhibitors representing 22 countries. The exhibit hall buzzed with energy as participants connected and explored potential partnerships. Floor selection is now open for the 2027 Calgary, Canada exhibition. To explore sponsorship and exhibiting options, please contact exhibits@asme.org.

A special thanks to the sponsors that supported the event. At the Platinum and most prestigious level were, Ansys, Avio Aero, Baker Hughes, GE Aerospace, GE Vernova, Siemens Energy, & Rolls-Royce. Our Gold sponsors were ENI, Honeywell & Pratt & Whitney. The Bronze level was supported by Cadence Design Systems, CBMM Technology Suisse SA, Dalian Windtuner Technology Co, Flownex Simulation Environment, NASA, Solar Turbines, & SoftinWay Incorporated.

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