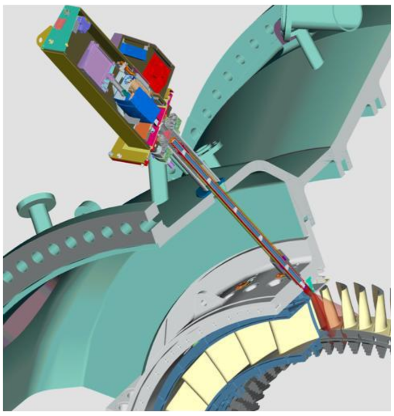
Advanced Multispectral Infrared Thermography



Gas turbine engines rely on the durability of hot-section components to achieve required performance, reliability, and safety. While high pressure turbines are exposed to gas path temperatures approaching their melting points, features such as cooling systems and environmental coatings are used in combination to meet design goals. The performance of these parts is critically dependent on the temperatures, cycles, and stresses achieved during engine operation. Thermometry systems offer nonintrusive optical temperature monitoring for hot-section diagnostics. However, their potential is currently hindered by poor absolute temperature accuracy (large error bounds) as a result of ill-characterized uncertainty sources. Modern applications attempt to circumvent this issue by empirical corrections (target specific calibration), which are particularly problematic for surfaces with low and varying emissivity, as encountered in most metals. Unlike most common monochromatic pyrometers, we are focusing our efforts on multi-spectral thermography of unknown emissivity surfaces. Although the emissivity is typically a function of both wavelength and temperature, on sufficiently close spectral bands, per-scenario assumptions (such as graybody, linear change with wavelength, etc.) are valid, and provide direct solution to the system matrix. By acquiring multi-integration time images and conducting quantitative image fusion considering total exposure non-linearity compensation, the currently developing optimized multispectral radiation thermography technique is geared towards accurate 2-D temperature measurement of hot target objects, absent of any repeated calibration.

Sound Generation by Periodic Joule Heating and Thermal Conduction Beyond the Fourier Law

In the Turbomachinery and Heat Transfer Laboratory, we have been investigating truly static and surface-deposited sound emitters. The enabling disruptive technology is a transducer, comprising of a periodically Joule heated electrically conductive thin layer, secured to a thin electrically insulating substrate. Lacking any moving parts, we have observed that the structure of these heat flux transducers (thermophones) is simple, reliable, neither takes up any significant space nor increases weight, can withstand high temperatures and be formed into large planar flexible sheets or manufactured by direct deposition through nano-fabrication. It is theoretically possible to create pure distortion-free sound in a broad frequency range. We have identified that the critical issues that prevent further system development and practical application are primarily associated with knowledge gap in adequate performance modelling of thermophone devices, which originates from lack of an accurate macro-scale conduction model that also captures non-Fourier heat transfer effects. Along these lines, the main objectives that will enable to tackle the problem are derivation of an accurate macro-scale heat conduction model that includes representation of non-Fourier effects and development of unified performance model for thermophone devices that create sound via thermo-acoustic effect.