Traditionally, intrusive instruments such as total pressure and total temperature probes have been used to measure compressible flow conditions. While these instruments are effective and widely used, they generate turbulence and produce blockage which could be undesirable in a variety of applications. Throughout this research, the use of non-intrusive acoustic measurements for flow velocity and temperature detection in compressible flow (Mach>0.3) environments was investigated. First, a novel acoustic technique was developed for compressible flow applications. The new approach was used to accurately measure single-stream jet velocities and temperatures in compressible flow conditions for the first time. Later research explored the use of this technique at the exhaust of a JT15D-1A turbofan research engine. Ultimately, 1.1 kg/s and 200 N root mean square errors in mass flow and thrust were observed for the tested engine conditions. Overall, the results of this experiment demonstrated that acoustic measurements could be used to estimate engine mass flow rate and thrust in a non-intrusive manner. The final portion of this research focuses on the non-intrusive detection of fluid velocity and temperature gradients. Since existing acoustic tomography techniques require an incompressible flow assumption, a novel approach has been proposed and used to perform a validation experiment in the single-stream jet facility. The recent experimental findings indicate that non-intrusive acoustic measurements could be used to measure velocity and temperature gradients in compressible flow environments as well. Further research is currently being conducted to better understand the accuracy limitations of the proposed tomography technique. To the authors' knowledge, this is the first time a non-intrusive acoustic technique has been used to characterize engine flows with Mach numbers greater than 0.3.

Figure 1: Non-intrusive (a) acoustic configuration and (b) measurement results at the exhaust of JT15D-1A turbofan research engine.
Recent Publications


Biography

Wing F. Ng has completed PhD from MIT Gas Turbine Lab and holds the Chris Kraft Endowed Professorship of Mechanical Engineering at Virginia Tech. Throughout his career, he has won many awards for his teaching, research and entrepreneurial activities. He has 35 years of research experience in gas turbine aerodynamics & heat transfer, has received 5 ASME best paper awards, and is an active advisor for NASA and the US Air Force. In addition to his full-time faculty role, he owns an engineering and manufacturing company by the name of Techsburg, Inc.

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