APPLICATION OF A SPLIT-FIBER PROBE TO VELOCITY AND TEMPERATURE MEASUREMENTS

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ABSTRACT

Understanding unsteady flow phenomena in turbomachinery requires simultaneous measurements of velocity and temperature fluctuations. Conventional hot-wire and hot-film techniques are highly sensitive to velocity variations, but their responses are also affected by temperature changes, making it challenging to separate the two quantities. This work investigates the application of a split-fiber probe for simultaneous measurements of velocity and temperature under aero-engine-representative Mach-number conditions. The probe performance is compared with that of a conventional single-sensor fiber-film probe used as a reference. Both probes are calibrated in a free-jet facility over a Mach-number range from 0.1 to 0.65. Controlled periodic disturbances are then introduced to generate fluctuations in velocity and temperature. The results demonstrate that the split-fiber probe accurately captures the imposed unsteady velocity field and resolves temperature oscillations. The study highlights the potential of the split-fiber probe as a compact measurement technique for unsteady turbomachinery applications requiring high spatial and temporal resolution.

INTRODUCTION

Advanced measurement techniques with high temporal resolution are essential for investigating unsteady flow structures in modern compressors and turbines. In non-isothermal turbomachinery flows, velocity and temperature fluctuations occur simultaneously and contribute to aerodynamic losses, secondary-flow development, and heat-transfer processes. Consequently, measurement techniques capable of resolving both quantities are required. Hot-wire anemometry is widely used because of its excellent frequency response and sensitivity to flow fluctuations. However, the sensor response depends on both velocity and temperature, requiring dedicated calibration procedures and signal-processing methods to separate the two effects [1]. Several approaches have been proposed, including multi-wire configurations operated at different overheat levels and dedicated temperature-compensation techniques [2]. While effective, these arrangements often increase probe size and measurement intrusiveness. Split-fiber probes offer an attractive alternative because two sensing elements are integrated on a single cylindrical support, providing high spatial resolution with limited flow blockage. Previous studies demonstrated their capability for unsteady velocity and flow-angle measurements in compressor environments [3]. The present work extends this concept to simultaneous measurements of velocity and temperature. The objective is to assess the feasibility of the split-fiber probe for unsteady turbomachinery flow investigations by comparing its response with that of a conventional single-sensor fiber-film probe.

RESULTS AND DISCUSSION

Both probes were calibrated in a free-jet facility using an automatic calibration system from Dantec Dynamics. Calibration covered Mach numbers between 0.1 and 0.65. For the single-sensor probe, calibration curves were obtained at different operating temperatures, while the split-fiber probe was additionally calibrated for different yaw angles to establish a complete response map. To evaluate the dynamic response, periodic

disturbances were introduced into the flow. Velocity fluctuations were generated using a siren system that imposed pressure oscillations at controlled frequencies. Temperature fluctuations were produced by periodically mixing two air streams at different temperatures downstream of a dedicated mixing section.
Figure 1 presents representative calibration results for the single-sensor fiber-film probe at two operating temperatures. The observed temperature dependence confirms the need to account for thermal effects in velocity measurements. Similar calibration behavior was obtained for the split-fiber probe.
The unsteady measurements show good agreement between the velocity fluctuations measured by the single-sensor and split-fiber probes. In addition, the split-fiber probe successfully detected the imposed temperature oscillations. These findings indicate that the probe can resolve simultaneous velocity and temperature fluctuations while maintaining the spatial advantages of a compact sensing geometry. The results demonstrate the suitability of the split-fiber probe for future applications in complex compressor and turbine flows.

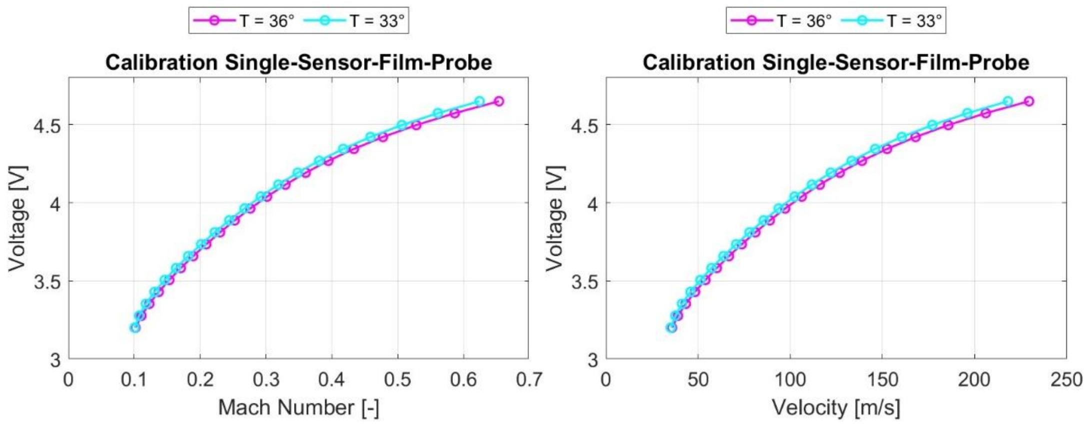

Figure 1. Calibration curves of the single-sensor fiber-film probe at two operating temperatures.

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