Investigation of sound-flow interaction at a bias flow liner using 3D/3C velocity measurement and Helmholtz-Hodge decomposition

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HIGHLIGHTS

• Simultaneous three component measurements of the fluid velocity at a bias flow liner in a three dimensional region of interest (1 cm³).
• The high dynamic range of 1500 allows the detection of both the flow velocity and the acoustic particle velocity.
• The separation of the measured fluid velocity into sound field and flow field is achieved using natural Helmholtz-Hodge decomposition.
• An aeroacoustic source is detected near the liner surface and the domination of turbulent oscillation in the velocity field is revealed.
• The high measurement rate of 100 kHz enables the detection of the turbulent flow behavior and the energy transfer from sound to flow.

ABSTRACT

In order to reduce the sound emission of modern gas turbines or jet engines, bias flow liners are used, where the damping of the sound is based on a complex interaction of sound wave and the bias flow injected through a perforated facing sheet. The optimization of these liners regarding a high damping efficiency necessitates a deeper understanding of the complex three dimensional (3D) aeroacoustic phenomena. To this aim, a contactless three-component vector (3C) measurement of both the flow velocity (in the order of several m/s) and the acoustic particle velocity (down to few mm/s) is presented here, employing a decomposition of the oscillation (see Fig. 1) of the measured velocity field. The work provides new insights to aeroacoustic damping phenomena.

Fig. 1 Oscillation \( \nu_{osc} \) of the measured fluid velocity at the central orifice of a bias flow liner and its divergence and curl.