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Aerodynamic noise reduction by plasma actuators for a flat plate with blunt trailing edge

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ABSTRACT

An experimental study of active control of the vortex shedding narrowband tonal noise radiated near the blunt trailing edge of a flat plate with elliptical leading edge was performed using three different configurations of the single dielectric barrier discharge (DBD) plasma actuators. These devices can produce electric winds in the tangential, downward and spanwise directions, respectively, near the blunt trailing edge. Acoustics and flow measurements were carried out simultaneously at Reynolds numbers between 0.75×10^5 and 4×10^5, based on the flat plate chord length, inside an aeroacoustic facility. The range of alternating-current (AC) input voltages to these plasma actuators was relatively low at < 5 kV. The "tangential" plasma actuator is not very effective in the suppression of vortex shedding tonal noise (maximum 1–2 dB reduction), although the spatial distribution of the wake coherent modes calculated from the proper orthogonal decomposition becomes more compact than that produced by the baseline plasma off case, resulting in a shift of the tone frequency to a higher value. The "downward" plasma actuator can suppress the vortex shedding noise almost completely at the tone frequency (about 15 dB reduction at input voltage of 4.2 kV). The mechanism is related to the induced plasma jet acting as a virtual barrier to inhibit the interaction between the upper and lower separating shear layers, and to delay the formation of the vortex shedding. The "spanwise" plasma actuator, which can project array of streamwise vortices into the wake and compartmentalise the vortex shedding across the span, demonstrated a more superior tonal noise reduction capability at low input voltage (about 12 dB reduction at 3.0 kV). It is found that the plasma-induced jet magnitudes between 9 and 10% and 7% of the freestream velocity for the downward and spanwise plasma actuators, respectively, are already sufficient to achieve an effective reduction of the vortex shedding tonal noise.

1. Introduction

The unsteady flow structure behind a bluff body or blunt trailing edge has been studied extensively due to its importance in many engineering applications. The separation of the free shear layer from the sharp corners of the blunt trailing edge, for example, can lead to formation of vortices that shed alternately from each side of the body. These coherent vortices along with the unsteady velocity field will produce a force loading that increases the aerodynamic drag. If the frequency of the vortex

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