Study of Airfoil Leading Edge Separation Control Using Pulsed Nanosecond Plasma Actuator

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Nanosecond (ns) dielectric barrier discharge (DBD) actuator is being investigated intensively as an effective actuation technique for aerodynamic bodies at high cruise speed. Nanosecond DBD causes the rapid, localized heating of near surface gas and generation of a micro shock wave. Compared with traditional alternating current (AC) plasma discharge, ns DBD induces much smaller flow velocity in neutral gas and actually functions via Joule heating effect. In this study, a combined numerical and experimental investigation of leading edge flow separation control over a NACA0015 airfoil is conducted to reveal which feature (i.e. the discharge induced shock or residual heat or both in combination) dominates ns DBD control authority. To this end, a well validated and verified self-similar plasma model[1] is loosely coupled with compressible Reynolds averaged Navier-Stokes (RANS) equations solver to model the effect of plasma discharge on external flow and resolve the detailed flow control process. In addition, wind-tunnel experiment is performed for two low Re flows to measure transient flow field with dynamic particle image velocimetry (PIV) system. The simulation and experiment complement each other and information missing from experiment is provided by simulation. The detailed flow actuation process is displayed and Fig. 1 shows the transient flow filed of controlled flow at Re=5×10[4]. It is found that the discharge produced residual heat rather than shock wave plays a dominant role in flow control. The mechanism of ns actuation is excitation of inherent flow instability or boundary layer tripping, which depends on both Reynolds number and angle of attack.

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[1] Zheng et al., *Phys. Fluids* **26**, 036102 (2014).

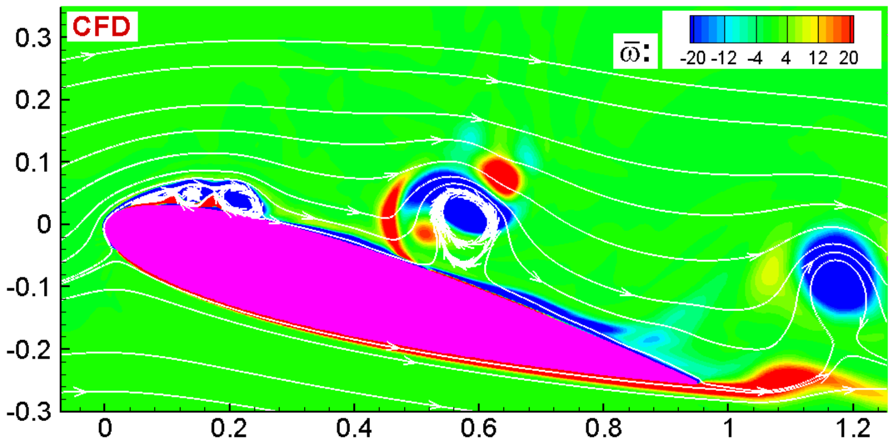

Figure 1: Vorticity field showing the controlled flow over a NACA0015 airfoil, Re=5×10[4] (U_∞=10m/s), AoA=15°.

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Design of Sonic Crystal Windows for meeting the Trio Challenges of Providing Natural Ventilation, Daylight and Noise Mitigation

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Traffic, construction and noise from human activities are common noise sources in major cities. Excessive noise can cause stress and health impacts. Sonic crystals have been reported as noise barriers for the reduction of traffic and environmental noise. The main aim of the study is to investigate the phenomenon of sound attenuation in sonic crystals using computer simulations and experiments as well as the design of a window incorporating sonic crystals for traffic noise mitigation. Bragg's law is one of the governing laws that are used to predict the center frequency of the band gap whereby sound is attenuated. The proposed sonic crystal window structure is in the form of multiple arrays of tubular columns with suitable spacing to target noise reduction for the frequency range of interest. In addition, other features such as noise absorbing materials and Helmholtz resonators can be incorporated into the tubular structures. The space and openings through the periodic tubular structures ensure a balance of natural ventilation and daylight. Finite Element Method (FEM) is also used to analyze two-dimensional (2D) and three-dimensional (3D) models as close to reality as possible. Experiments were then carried out to determine the similarities and differences between experimental and simulation results.

Keywords: Sonic crystals, Noise mitigation, Environmental noise, Finite element analysis