Control of Vortex-Structure Interaction Noise Generation on a Rod-Airfoil Configuration

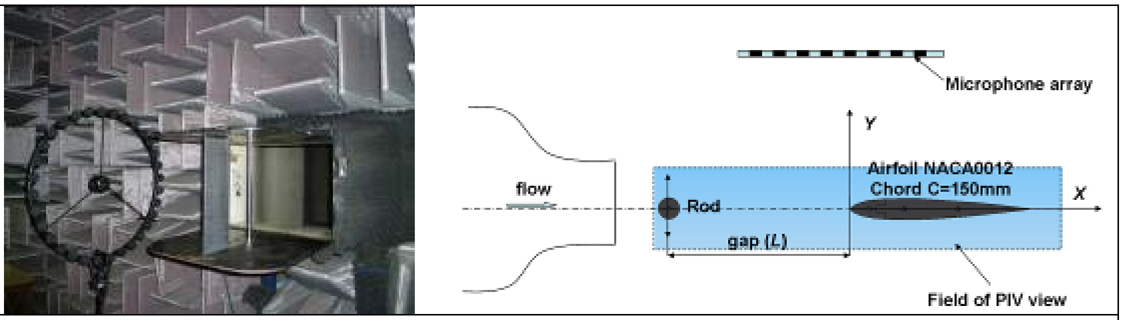
Y. Li, X. N. Wang, Z.W. Chen, D. J. Zhang
China Aerodynamics Research and Development Center,
Mianyang, Si Chuan, China, 621000

Introduction

Vortex-structure interaction noise is of main concern in several aeronautical and industrial applications. Two important devices involving such interaction noise are the rotor configurations of turbo-engine and helicopter rotors, in which the downstream airfoil blades are embedded in the wake of upstream blades. At any given time, the vortices shed from the leading blades interact with and impinge upon the trailing blades, giving rise to a host of noise and vibration issues. The rod-airfoil configuration consisting of an airfoil located in the near wake of a rod is believed to be a generic model of the vortex-structure interaction noise. This configuration has been widely investigated both numerically and experimentally[1-2]. Since the dominant noise source for a rod-airfoil configuration is the impingement of the Karman vortices onto the airfoil leading edge, a modification of the leading edge aerodynamics is expected to modify both the sound emission and the flow of the rod-airfoil [3].In this work, the interaction noise is modified by manipulating the flow along its contour, applying air blowing and soft vane on the airfoil leading edge.

Methodology

A NACA0012 airfoil with a chord length(C) of 150mm is located downstream of a rod with diameter of 15mm. Experiments were conducted in the Aeroacoustic wind tunnel of CARDC.The rod-airfoil model is vertically installed between two endplates which are mounted at two opposing sides of the wind tunnel nozzle(Fig.1). Measurements using phased microphone array and PIV have been performed at free stream velocities U=30m/s and 60m/s.



(a) (b)

Fig.1 Wind tunnel test setup. **(a)** Near view showing the model between two end plates; **(b)** Sketch of the rod-airfoil configuration and of the coordinate system (top view, not to scale).

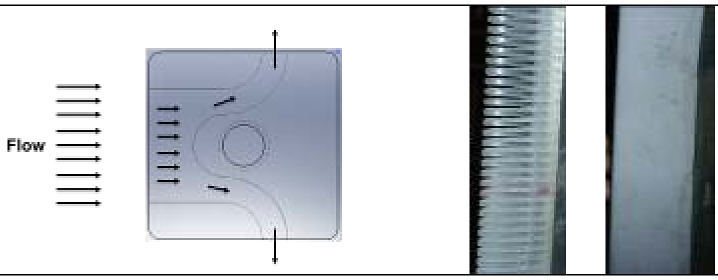


Fig.2 Photographs of noise control devices. Air blowing rod(left) and Soft vane(right).

Two noise reduction concepts, air blowing device and soft vane are developed. The first device is a square cylinder with two 3mm-width orifices, from which the air blows vertically (Fig.2a). The second of these concepts is the soft vane (Fig. 2b), wherein the airfoil leading edge is made slotted and covered with thickness cloth.

Results

The effects of the air blowing rod and soft vane on the noise reduction are assessed. Fig. 3 shows the noise map comparison between the air blowing rod and the square rod at the free stream velocities of 30m/s. It can be seen that the major noise sources located in the airfoil leading edge area are reduced by about 3.8dB with the air blowing rod. The noise reduction maps for the soft vane are shown in Fig.4. that the slotted leading edge gives a 3dB noise reduction, whereas a noise reduction of 5dB can be obtained with the soft vane by covering the slotted leading edge with cloth.

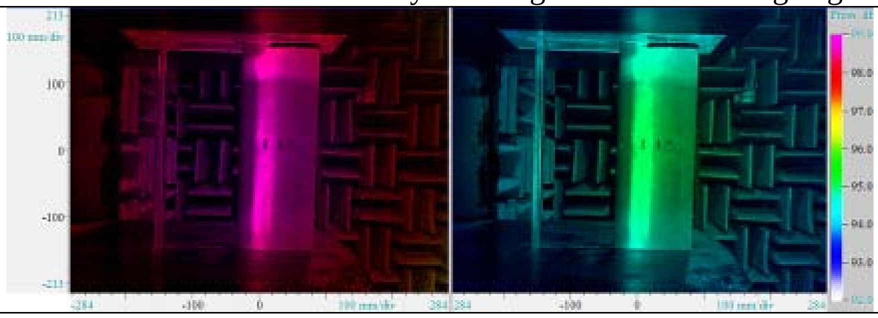


Fig.3 Noise map comparison showing the noise reduction using air blowing rod at speed of 60m/s

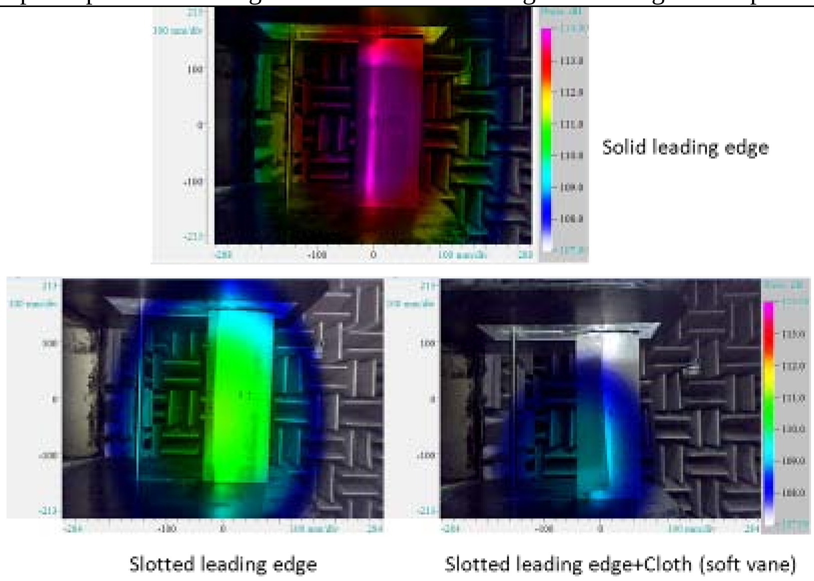


Fig.4 Noise map comparison showing the noise reduction using soft vane at wind speed of 60m/s.

The PIV measurements will be carried out in the same wind tunnel later, and the final paper will present a variety of PIV measurements, microphone array data and far-field acoustic data indicating the noise control effects of the vortex-stucture interaction noise using the control concepts.

References

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