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ACTIVE CONTROL OF NOISE GENERATION IN A ROD-AIRFOIL CONFIGURATION

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Abstract. Flow control and adaptive techniques have been widely investigated as possible noise reduction approaches in modern aviation. Despite extensive studies realized on the aerodynamics of a rotating cylinder (i.e. [1, 2]), its potential as a noise reduction technique has not been investigated in the context of an airframe configuration. In the present paper, the aeroacoustic effects of cylinder rotation are investigated in the rod-airfoil canonical benchmark [3]. A 2D hybrid computational aeroacoustics approach is used for noise prediction. Rotation is introduced to the cylinder at rotational frequencies ranging from 1/32 to 2 times the shedding frequency of the non-rotating case. Overall noise directivities and acoustic spectra are then computed for all cases, using the Ffowcs-Williams and Hawkings equation [4]. Evaluation of all test cases proves that significant noise reduction may be achieved by a cylinder rotating at frequencies higher than the shedding frequency of the non-rotating case. Since suppression of the vortex shedding is expected at high enough rotational velocities [5], additional study of the flow field leads to interconnection of noise reduction with this phenomenon. As is observed by the flow field around the rod and airfoil, the cases that present reduced noise emissions also present gradual suppression of the vortex shedding, which is the main contributor to noise generation. High cylinder rotational frequencies also lead to significant increase of the vortex shedding frequency of the rotating cylinder, while the shift of the vortex shedding frequency additionally leads to a shift of the dominant tones of the acoustic spectra. The present investigation thus proved for the first time the potential of cylinder rotation as an adaptive technique for noise reduction, in airframe configurations. A rotating cylinder offers the capability of reducing the noise levels, while altering the directivity pattern and acoustic spectra, thus finding potential application as part of aircraft or UAV airframe components, landing gear, propulsion devices etc. Future work should include a fully unsteady 3D simulation, focused on the rotating frequencies of interest, in order to account for turbulent and three-dimensional noise generation mechanisms.

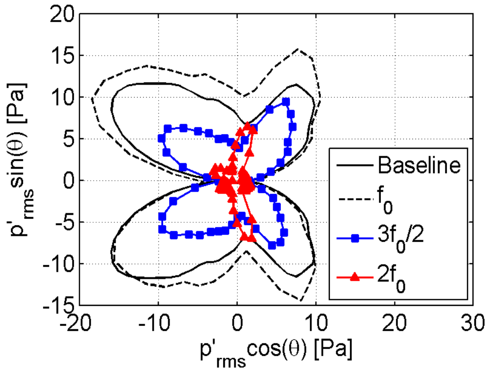

Fig. 1. Noise directivity for 100 observers located on a circle of 1.85 m radius from the airfoil center. No rotation: continuous line; Rotation by f_c: dashed line; Rotation by $3f_c/2$: squares; Rotation by $2f_c$: triangles

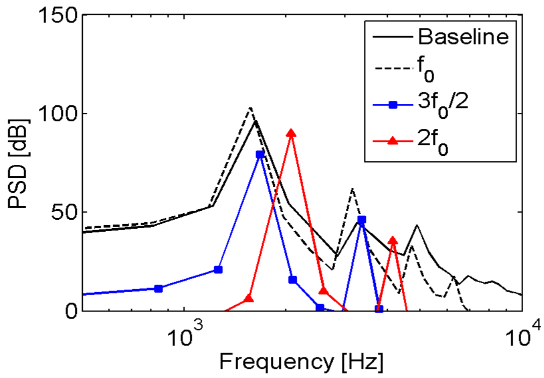

Fig. 2. Acoustic far field for an observer located at 1.85 m above the airfoil center. No rotation: continuous line; Rotation by f_c: dashed line; Rotation by $3f_c/2$: squares; Rotation by $2f_c$: triangles

Keywords: airframe noise, noise reduction, flow control, adaptive techniques, rotating cylinder.

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