Flexible trailing edge as a passive noise reduction device for installed jet noise

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Introduction

The increasing size of the aircraft engines is leading to reconsider their conventional underwing installation due to the significant rise of noise emissions associated with the interaction between the jet and the airframe surfaces. Noise reduction devices are explored by manufacturers in order to mitigate the jet installation effects. Motivated by these concerns, we carry out an experimental investigation of the jet-surface interaction phenomena in a simplified configuration consisting of a jet interacting with a parallel flat plate and explore the noise reduction obtained by considering a flexible trailing edge. We show that flexibility modifies the dipole nature of the trailing edge noise source inducing a sound radiation reduction which is function of the streamwise length of the flexible insert and the jet flow velocity.

Experimental setup

An experimental test campaign has been performed in the *Bruit & Vent* anechoic facility at *Prométée*, the technological platform of *Institut Pprime* in Poitiers. A subsonic, isothermal jet issuing from a convergent nozzle of diameter $D = 0.05m$ is installed within the anechoic chamber.

Two types of flat plate were installed parallel to the jet at a radial distance $H = 1D$ from the nozzle axis with the trailing edge positioned at the axial distance $x/D = 2$: (i) a rigid plate and (ii) a plate with flexible trailing edge. The flexible material is inserted on the plate so as to not change the distance of the trailing edge from the nozzle exit. We investigated different lengths l of the flexible insert in the streamwise direction, ranging from $0.1D$ to $1.2D$. The thickness of the flexible TE was about $0.01D$. We considered two flexible plate configurations: (i) a plate with a one-piece flexible insert and (ii) a plate with a snipped flexible insert with snips placed along the streamwise direction. The snips introduce an additional degree of freedom to the flexible slice along the spanwise direction generating a sort of 'permeability' to the pressure fluctuations induced by the jet. This additional degree of freedom implies that the response of the flexible insert is not the same along the spanwise direction. A picture of the different plate configurations herein considered for the composite material with glass fibres is shown in Figure 1.

A 6-microphone azimuthal array was placed at the nozzle exhaust at a radial distance of $r = 0.9D$ from the nozzle axis to measure the pressure fluctuations in the near field and to extract the azimuthal Fourier mode $m = 0$, which is the most efficient mode in terms of noise emissions in an installed configuration [1]. Two far-field microphones were placed at the TE axial position at a radial distance of $26D$ from the trailing edge in both the shielded and unshielded sides of the acoustic field where the dipole TE noise source has its maximum emissivity. Measurements were carried out in isothermal conditions for different jet Mach numbers ranging from $M = 0.15$ to $M = 0.75$.

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Figure 1. Pictures of the different jet-plate configurations investigated.

Experimental results

A global assessment of the flexible trailing edge as a passive noise reduction technology is provided by the band-limited OverAll Sound Pressure Level ($BLOASPL$). Figure 2 shows the $\Delta BLOASPL$ between the rigid and flexible plate configurations as a function of jet Mach number M and flexible length l/D. The snipped flexible trailing edge is much more efficient in reducing far-field noise than the one-piece flexible trailing edge. Noise reduction is more significant for low M and high l/D values. Specifically, the maximum noise decrease is achieved when the flexible length is of the order of the nozzle diameter and, mostly important, of the large-scale coherent structures which are known to be the most efficient structures for noise emissions in a jet [2]. The reduced effectiveness of flexibility in reducing installed noise for increasing M could be likely ascribed to the dominance of the 'direct' jet noise over the scattered one for increasing jet velocities [3].

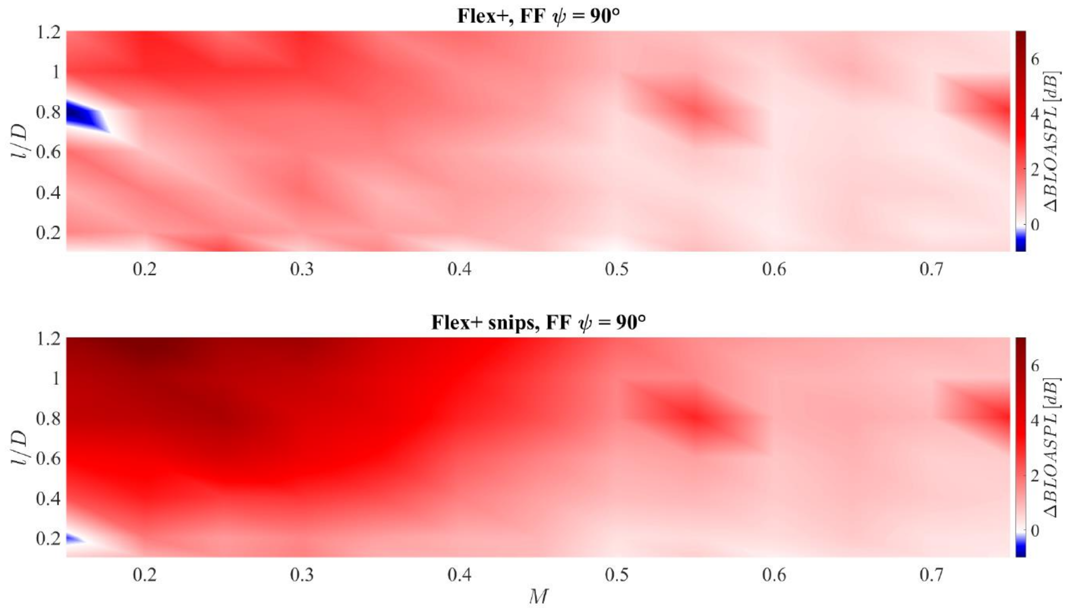

Figure 2. Δ band-limited $OASPL$ between rigid and flexible configurations.

References

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