11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

EFFECT OF UPSTREAM FLOW CONDITIONS ON ACOUSTIC FEEDBACK-LOOP INTERACTIONS IN TRANSITIONAL AIRFOILS

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Key Words: *ILES, Transitional Airfoil, Flow-Acoustic Interactions, Upstream Conditions*

Recent numerical efforts are discussed examining effects of upstream flow conditions on the acoustic feedback-loop mechanism of flow-acoustic resonant interactions in transitional airfoil boundary layers (Fig. 1). In our previous works [1-2], experimentally recorded unsteady responses of loaded, transitional NACA0012 airfoil confirmed the presence of the shifted ladder-type tonal structures with dual velocity dependence observed in the surface pressure and the acoustic signals. High-fidelity numerical efforts employ a 6^{th}-order Navier-Stokes solver implementing a low-pass filtering of poorly resolved high-frequency solution content to retain numerical accuracy and stability over the range of transitional flow regimes. 2D and 3D (ILES) numerical experiments investigate the behavior of the boundary-layer statistical moments during the transitional flow regimes characterized by the presence of separation regions and the resulting formation of the highly-amplified instability waves scattered into noise at the airfoil trailing edge, thus triggering and sustaining the acoustic feedback-loop process. The current paper extends the previous numerical studies [1-2] by focusing on the sensitivity of the airfoil flow-acoustic interactions (and the resulting acoustic signature) to the upstream flow conditions. In particular, the following aspects of the problem are addressed: (i) The effect of the upstream free-jet flow, with objective to more closely represent the experimental set-up and thus provide a better match with experiment in the broadband frequency-response spectrum (Fig. 2), and (ii) The effect of upstream turbulence, with the analysis employing a recently developed novel numerical procedure [3-4].

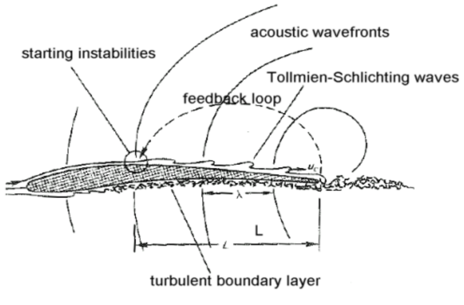

Fig. 1. Acoustic feedback loop in transitional airfoil flow-acoustic interactions.

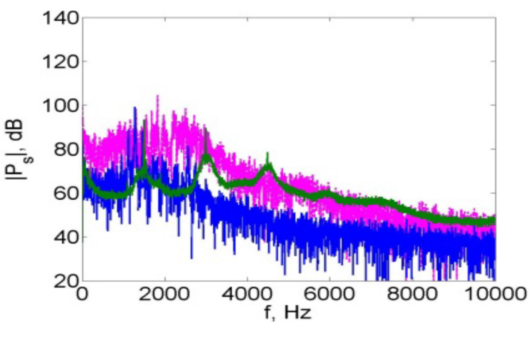

Fig. 2. Comparison of 2D (magenta) and 3D (blue) predicted vs. measured (green) airfoil surface pressure spectra at the midchord suction-side location, for U=25 m/s.

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