Flow-induced noise produced by a blunt edged flat plate in a reverberant water tunnel

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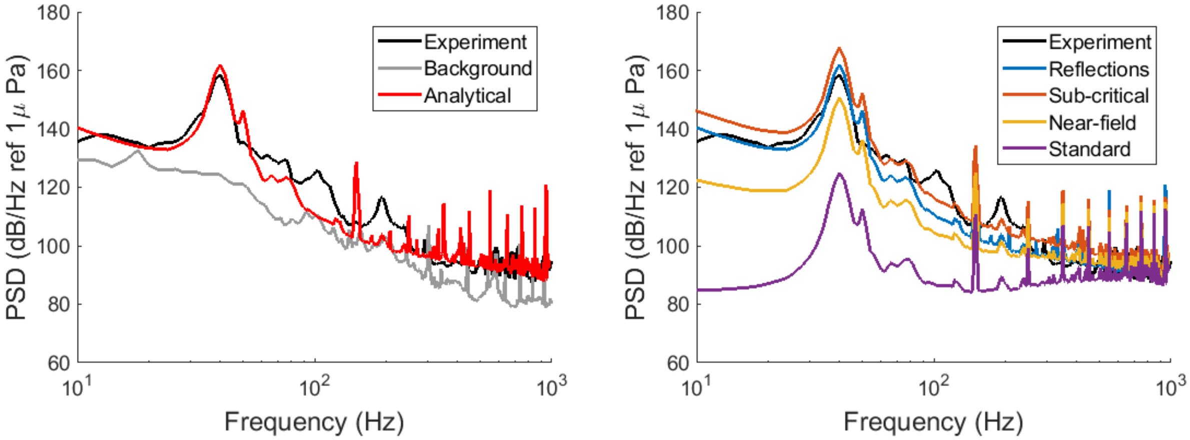
A numerical and experimental investigation into the flow and noise produced by a blunt-edged flat plate with a Reynolds number based on chord of 6.8 million and a Mach number of 0.0053 is presented. The flat plate had a 4:1 aspect ratio elliptic leading edge and a square trailing edge with a thickness-to-chord ratio of 0.0054. Experimental measurements were performed in the cavitation tunnel at the Cavitation Research Laboratory within the Australian Maritime College. Pressure sensors were flush mounted on the top, bottom and rear faces of the blunt edge at the mid-span plane. Further, a hydrophone was mounted in a flooded cavity in the tunnel wall beneath a polyurethane diaphragm, as described in [1].

An analytical model from Roger and Moreau [2, 3] is extended here to account for near-field effects and to consider reflection of pressure waves by the duct walls. Trailing edge pressure measurements from the top and bottom faces of the blunt trailing edge are combined with the modified trailing edge scattering model, to predict the pressure at the hydrophone located in the cavitation tunnel wall. Figure 1(a) compares the predicted and measured pressures, showing excellent agreement at the vortex shedding frequency. Good agreement between the high frequency content of the predicted and measured pressures can also be observed. The analytical results do not accurately capture the peaks associated with the 2nd and 4th harmonics of the vortex shedding frequency. This is attributed to the scattered pressure on the rear face of the blunt edge not being included in the present analysis, and is currently being investigated.

Figure 1(b) presents changes in predicted pressure from incremental enhancements to the scattering model. The ‘standard’ curve represents the result obtained using the analytical scattering model of Roger and Moreau [2, 3], including leading edge back-scattering but considering only super-critical wavenumbers. The ‘near-field’ curve shows the incremental change when the influence of near-field effects are included in the analytical model. The ‘sub-critical’ curve presents the additional effect arising from inclusion of sub-critical wavenumbers. The ‘reflections’ curve further considers the reflection of the pressure from the rigid duct walls. Figure 1(b) show that both near-field effects and sub-critical wavenumbers contribute significantly to the predicted pressure for this case study. Sub-critical wavenumbers produce evanescent pressure waves which decay rapidly away from the source region and typically do not radiate to the far field as sound. However, in the current study, the receiver hydrophone is well within the near field of the source region. Hence sub-critical wavenumbers and near-field propagation effects must be included to give an accurate estimate of the pressure. This has implications for using analytical scattering models to predict pressure in other marine flow applications, such as prediction of hull pressures due to the rotation of a nearby propeller.



(a) (b)

Figure 1: (a) In-wall hydrophone pressures, and (b) changes in predicted pressure with incremental enhancement of the analytical scattering model

References

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