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Session:

High-order implicit large eddy simulation for a high-lift airfoil configuration

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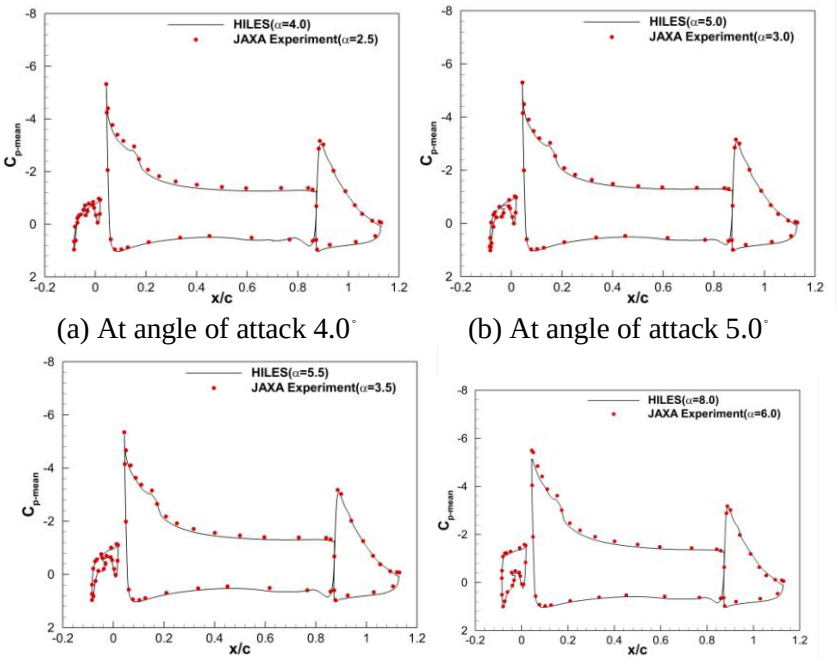
Abstract

A series of high-order implicit large eddy simulations (HILES) with nine angles of attack have been carried out to investigate the flow mechanism over the slat element of the 30p30n configuration. A high-order dissipative compact difference scheme is employed for this HILES. The numerical simulations have been validated by comparing the correspondingly experimental data. The investigation indicates that the tonal components in the low frequency range of the slat noise can be explained by a feedback loop mechanism. The HILES solutions have been further utilized to model the feedback mechanism with attack angle effect by fitting the parameters dominated by local flow characteristics.



(a) At angle of attack 4.0° (b) At angle of attack 5.0°

(c) At angle of attack 5.5° (d) At angle of attack 6.0°

Fig. 1 Comparisons of surface pressure distributions.

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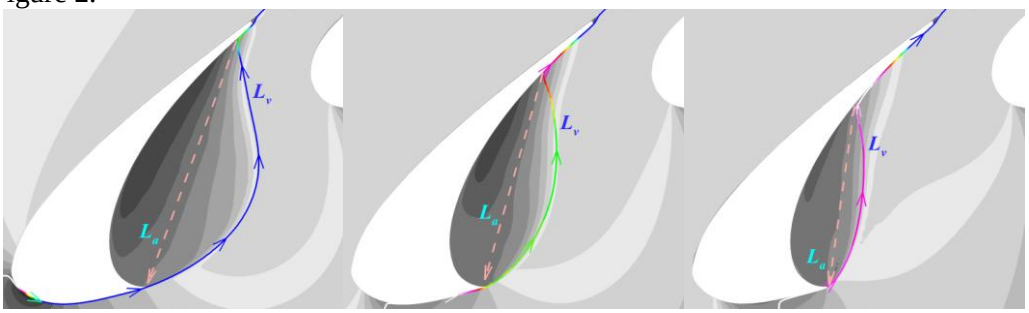
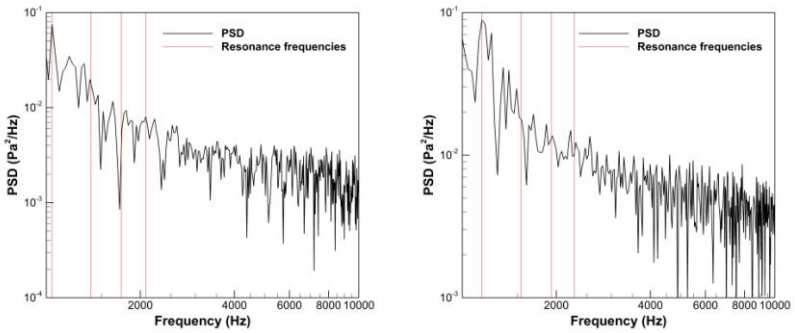
Figure 1 shows the mean surface pressure coefficients at four different angles of attack compared with the experimental data [1]. The HILES results are in good agreement with the experimental data. The tonal components in the relatively low frequency range of pressure signal are related to a feedback mechanism between the main shear layer and the acoustic waves generated by the impingement of the shear layer on the slat lower surface [2]. The trajectory of the mean shear layer is defined by the mean streamline at the critical point that the mean flow direction switches from towards the slat cove to towards the slat gap, as shown in Figure 2.



(a) At angle of attack 3.0° (b) At angle of attack 12.0° (c) At angle of attack 20.0°

Fig.2 Mean shear layer trajectories and schematic feedback loop at different free-air angles of attack.



(a) At angle of attack 4.0° (b) At angle of attack 12.0°

Fig. 3 Predicted resonance frequencies in the PSD of the square of the fluctuating pressures.

Based on the HILES solutions, the feedback mechanism is modelled with attack angle effect. The predicted resonance frequencies of the modelled feedback mechanism are shown in Figure 3 together with the PSD of the square of the fluctuating pressures. The narrow-band peaks indicated by the PSD have good agreement with the predicted resonant tonal frequencies.

References

[1] Murayama, M., Nakakita, K., Yamamoto, K., Ura, H., Ito, Y., and Choudhari, M. M., Experimental study of Slat noise from 30P30N three-element high-lift airfoil in JAXA hard-wall low-speed wind tunnel, AIAA paper 2014-2080, 2014.

[2] Terracol, M., Manoha, E., and Lemoine, B., Investigation of the unsteady flow and noise sources generation in a slat cove, AIAA Journal 54(2) (2016) 469-489. DOI: 10.2514/1.J053479.