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Transition Effect on the Vertical Flow past the VFE-2 Delta Wing with Rounded Leading Edge

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Introduction

It has been demonstrated that the primary separation is fixed at the sharp leading-edge of delta wing. However, the vertical flows become much more complicated when the leading-edge is round because the position of primary separation varies with the leading-edge radius, angle of attack, Reynolds number, transition location, and so on.

Two problems are still remaining, such as the vortex breakdown and the region of the secondary vortex. RANS-LES Hybrid method always fails in accurate predicting the position and pattern of vortex breakdown, leading to the deviation of pressure fluctuation from the experiments. For the secondary vortex, it's very difficult to accurately predict the strength and location [1].

In this study, DDES based on the three–equation k-ω-γ transition model (DDES-Tr) is proposed to investigate the influence of natural transition on separation position past the VFE-2 delta wing with medium rounded leading-edge. The k-ω-γ transition model has been improved and validated on blunt cones in our previous work [2].

Preliminary Results

Figure 1 shows the pressure coefficients on two streamwise sections. It is noted that the transition can well capture the weak change of pressure, especially at section of x/c=0.6. The full turbulence model shows only one strong primary vortex. While the DDES-Tr presents both the primary vortex and an inner vortex, which is accordance with the experiments.

Isosurface of Q criterion by DDES is shown in Figure 2. Moderate separation can be observed on the leeward side. It is a challenge for predicting the sensitive location of separation and vortex breakdown. Figure 2 shows the distribution of intermittency factor γ on the surface of VFE-2. It can be seen from the distribution of intermittency factor γ on the leeward side, the laminar region only exists in a small area at the leading-

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edge of the apex. Nevertheless, such small transition region affects the flow pattern so much.

Following work

In the following work, k-ω-γ transition model will be implemented into the DDES to improve the prediction of pressure fluctuation on surface of VFE-2 delta wing.

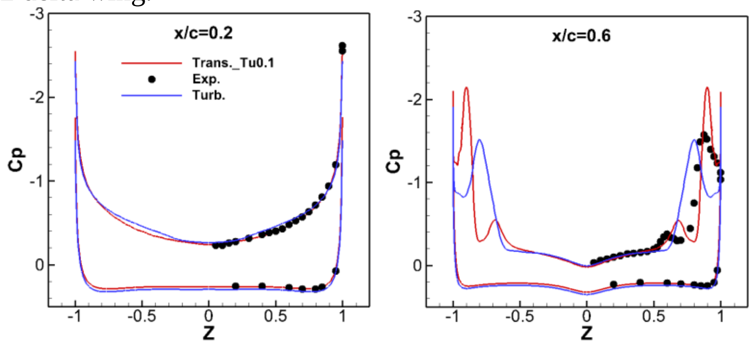

Fig. 1 Pressure coefficients on different sections along streamwise direction.

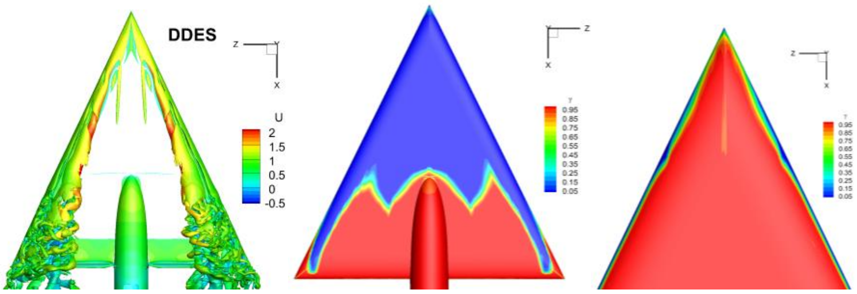

Fig. 2 Left: isosurface of Q criterion; The distribution of intermittency factor γ on the surface of VFE-2.(Middle: windward; Right: leeward.)

References

[1] Willy Fritz. Numerical simulation of the peculiar subsonic flow-field about the VFE-2 delta wing with rounded leading edge. Aerospace Science and Technology. 24 (2013) 45-55.

[2] Guangxing Wang, Muchen Yang, Zhixiang Xiao, Song Fu. Improved k-ω-γ transition model by introducing the local effects of nose bluntness for hypersonic heat transfer. Int. Journal of Heat and Mass Transfer. 119 (2018) 185-198.