

Influence of inflow turbulence intensity on static and dynamic stall of NACA 0021 at $Re = 5.5 \times 10^6$ using DDES method

The authors simulate static and ramp-type dynamic stall of a NACA 0021 at $Re = 5.5 \times 10^6$ with URANS and SST-DDES. They examine the spanwise domain length ($0.25c$, $2.5c$), compare URANS with DDES, and vary the apparent inflow turbulence intensity (0.5–9.6%). The topic is relevant and the dataset well chosen, but the novelty is incremental and should be stated explicitly.

I recommend **major revision**. The main concerns are the representation of inflow turbulence, the DDES resolution (particularly in the wake), the grid and span-length convergence, and the uncertainty of the corrected experimental data.

1. **Inflow turbulence.** Only modelled k and ω are imposed. TI therefore acts solely through freestream eddy viscosity entering the RANS-mode boundary layer, and mixing by resolved freestream eddies (Huang et al., 2020) cannot occur. Report the inlet k and ω (or ν_t/ν), the probe location and the decay to the leading edge.

The LES mode upstream of the leading edge (Fig. 9d) makes the TI reaching the airfoil grid-dependent. The best agreement occurs at TI = 3.6%, against a tunnel TI of 0.3–1.1%, so TI is acting as a tuning parameter. Either add a synthetic-inflow case or frame the study as a sensitivity of SST-DDES to *modelled* freestream turbulence.

2. **DDES resolution, particularly in the wake.** The 0.46M-cell grid (25 spanwise cells, $\Delta z = 0.1c$) is URANS-grade. Fig. 3 shows rapid cell growth downstream, yet Fig. 9d shows LES mode over the whole wake. A stall cell of 1–2c gets only 10–20 spanwise cells, and with `linearUpwind` convection the numerical dissipation likely exceeds the SGS contribution.

Please give the wake cell sizes and the filter-width definition (`maxDeltaxyzCoeffs = 2` is merely the default). Then *systematically refine and coarsen the wake/LES region*, e.g. halving and quartering $\Delta x, \Delta y, \Delta z$ in a box 2–3c downstream with the near-wall grid fixed. Report the effect on mean loads, spanwise variation, fluctuation amplitude and the spectral peak, together with the resolved-to-total TKE fraction.

Fig. 9c compares total modelled k (URANS) with subgrid k (DDES), which is not like-for-like. The negligible cost follows from sharing a URANS-grade grid. Also please report the CPU cost.

3. **Grid convergence (Appendix A).** The refinement ratios ($r \approx 1.21$ and 4.7) are non-systematic and convergence is oscillatory, yet a GCI of 0.01% is reported despite 2–4% differences between the reference and fine grids. Supply the force values and the observed-order calculation in appendix for reproducibility.

Only mean loads at one angle are assessed, while the conclusions rely on fluctuations, spanwise variation and spectra, which the authors admit differ between grids. Add an intermediate grid at a constant ratio, a time-step check, and the statistical uncertainty of the 10 s averages or logic behind this should be stated clearly for reproducibility.

4. **Spanwise domain length.** Only $0.25c$ and $2.5c$ are tested, with URANS plus the transition model, and with Δz differing tenfold. Add $L_z = 0.5c, 1.5c$ and $\approx 8c$ at fixed Δz using DDES, at stall onset and in deep stall, and discuss loads, stall-cell number/wavelength and spectra versus L_z/c . A periodic $1.5c$ case, combined with the AR = 1.5 slip-wall case (Appendix C), would separate span-length from wall effects. If AR is 0.25, it is recommended to use periodic conditions for 2 and above it may be tested with both periodic and symmetry conditions if the authors want to establish the effect of spanwise BCs.

5. **Transition model.** Justify using $\gamma-Re_\theta$ at $Re = 5.5 \times 10^6$: transition effects on stall matter mainly at $Re = O(10^5)$. At TI = 2 and 4.8%, the onset correlation forces leading-edge transition almost by construction ($Re_{\theta t} \approx 260$ at Tu = 2% vs. ≈ 880 at 0.5%). The fully turbulent check

is therefore near-circular; repeat it at the experimental TI and show the predicted transition location.

Explain the deviation at 18° , $TI = 4.8\%$ (Appendix B). The model is also used in the AR study and the dynamic URANS (Cases 1, 4), contrary to L237.

6. Experimental comparison.

- The α correction ($26^\circ \rightarrow 17.5^\circ$) has an uncertainty of $\geq 1-2^\circ$, comparable to the effects studied.
- The static data are at $Re = 5.0 \times 10^6$, not 5.5×10^6 .
- The measured C_d is 4–5 times the XFOIL value in attached flow, so it is not a 2D sectional drag; drop the C_d validation claims (incl. L318).
- Fig. 8 compares uncorrected c_p with simulations at the corrected angle.
- In Appendix C, with walls modelled, compare with uncorrected data at the geometric angle and use midspan values.

7. Static stall and the TI trend.

With $\sim 1^\circ$ spacing near stall and five TI levels, the change at $TI \approx 4\%$ is a trend between sampled cases, not a threshold. Define the stall-onset criterion, and support the stall-type and enhanced mixing claims with separation location, C_f and ν_t data.

State how the static runs are initialised. In Fig. 12a, $C_l \approx 1.5$ persists at 20.3° up to $t^* = 80$ for $TI \geq 4.8\%$, versus $\approx 1.1-1.4$ in the static polar, which suggests hysteresis.

8. Dynamic stall.

The mapping to Pitching A/B is unclear (how is 25.17° obtained?), and the peak $\dot{\alpha}c/(2U_\infty)$ differs: ≈ 0.007 (A), 0.012 (B), 0.009 (experiment). Give the pivot, motion law and initialisation, and use several realisations. Stall occurs after the motion stops, so the negligible TI effect during pitching is partly definitional; $TI = 9.6\%$ delays stall to $t^* \approx 55$. The “momentum” argument (L324, L378) is ill-defined.

9. Spectral analysis.

Define f^* consistently: the abstract quotes $St = 0.5$, the conclusions $St \sim 0.1$, and L (L280) is undefined. Scaled with $c \sin \alpha$, the static peaks give $St_h \approx 0.035$ at both angles, about five times below bluff-body shedding, which suggests a low-frequency stall-cell mode. The post-pitch peak gives $St_h \approx 0.21$, i.e. classical shedding, and it persists to $t^* \approx 60$ in Fig. 13e, so revisit the decaying-DSV interpretation.

Give the processing parameters, and note that moving-average detrending high-pass filters $f^* \sim 0.1$. Fig. 10 is labelled dB/Hz but shows powers of ten.

Minor comments

- **Conclusions.** The claims of “accurate” abrupt stall (DDES $C_l \approx 1.0$ vs. 0.7 at 19°), “negligible cost” and “fully turbulent” are overstated. Objective 1 is validation, not verification.
- Define Q3D, Tr, α_{ss} , TI, f^* and t^* ; give the unit of c and ν (L115) and the correction formulas (L117–124); L170 *cyclic*AMI vs. *cyclic*; L19–20 rotor tools are BEM-based; L56–57 cite a standard correction reference; L89–90 the Ekman layer is not laminar and tips do not reach 500–1000 m; L139 rephrase “validate the low Mach condition”; L254 maximum thickness is at $x/c = 0.3$; unify α_{ss} ($17^\circ/17.5^\circ/17.3^\circ$); Table 1 should list inlet values, pitching case and the transition treatment of the URANS pitching cases; share case files, force histories and scripts.
- **Figures.** Fig. 1: add α , TI, method and iso-quantity; Figs. 2/4: Re mismatch; symbol meanings differ between Figs. 5, 7 and B1; Fig. 8: panel sets differ and the C_l ranges are undefined; Fig. 9: k units and LES criterion missing; Fig. 11b: shading undefined; Fig. 12: α curve has no axis on the C_l panels, unlabelled inset, 3.6% missing in (a), duplicated hidden axes in (b); Fig. 13: “10” should be “−10” in (b, d, e) and the vertical lines are unexplained.
- **Language.**

- L16 “are ranging” → “range”.
- L20 “are featured with” → “are supplemented with”; “nearstall” → “near-stall”.
- L35 “where they” → “who”.
- L40 “once stall onset” → “once stall sets in”.
- L43 “constrast” → “contrast”.
- L48 “coefficients reaches” → “coefficient reaches”.
- L56 “tipvortices” → “tip vortices”.
- L62 “increasing” → “increases”.
- L68 “Reydnols” → “Reynolds”.
- L73 “LES simulations” is redundant.
- L89 “regimes-from” → em dash.
- L121 “continuos” → “continuous”.
- L127–128 “have not been validated in literatures” → “has not been validated in the literature” (also L306).
- L132 “farfiled” → “farfield”.
- L177 “quater-period” → “quarter-period”.
- L183 “speficied” → “specified”.
- L217 comma splice.
- L236 “aformentioned” → “aforementioned”; “is found” → “are given”.
- L269 “DES” → “DDES”.
- L271 “adversed” → “adverse”.
- L285 “Figure.” → “Figure”; “aee” → “see”.
- L291 “turbulent intensity” → “turbulence intensity”; “nearly different” → “nearly identical” (meaning reversed).
- L292 “> 4.8%” → “≥ 4.8%”.
- L304 “approach” → “approach”.
- L309 “< 2%” → “≤ 2%”.
- L321 rephrase “which is the decaying characteristics”.
- L347 “Fig 10” → “Fig. 10”.
- L383–385 run-on sentence.
- L404 “in representative cell size” → “versus representative cell size”.
- L405, Figs. A1/B1 “shared” → “shaded”; Fig. A1 “timely” → “temporal”.
- L416 “This results confirms” → “These results confirm”.
- L432 “cometing interest are” → “competing interests are”.
- L433 “Foundataion” → “Foundation”.
- L435 “Servies” → “Services”.
- Fig. 2 “of of”.
- Fig. 11b “tailing-edge”, “onet”, “Indifference”.