

## NEAR WALL TURBULENCE CONTROL USING CIRCULAR CAVITIES

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Drag reduction is nowadays a major task in civil aviation. The Advisory Council of Aeronautics Research in Europe (ACARE) has recently prescribed 75% cut of  $CO_2$  emissions per passenger-mile with respect to 2000's level. In cruise condition, 1% of drag reduction is translated into a 0.75% in fuel-burn savings [4]. The turbulent boundary layer developing of an aircraft surfaces is responsible for almost 60% of the total drag in cruise condition.

The passive control of near wall turbulence by means of a staggered array of cavity is addressed in the paper. Accurate boundary layer surveys and Particle Image Velocimetry (PIV) measurements are conducted in the low speed wind tunnel of ISAE-SUPAERO. The test model is a flat plate equipped with a square insert panel. Different insert panels are tested: a smooth baseline surface and models with different arrays of circular cavities. The Reynolds number based on the momentum thickness is between 1440 and 3380.

The results evidence a thickening of the viscous sublayer with a consequent upward shift of the logarithmic region. The application of the VITA technique [1] reveals a reduction of the burst intensity (defined as the peak-to-peak value of the conditionally sampled streamwise velocity [5]) as well as a shift of the peak of the burst frequency away from the wall. The burst frequency is shifted by  $\Delta y^+ \cong 5$  and can be seen as a confirmation of the thickening of the viscous sublayer found in the mean velocity profile. From the PIV data a similar shift is evidenced in the production term of the turbulent kinetic energy budget. The quadrant analysis suggests that this is due to an increase in ejections and a decrease in the sweeps. The cavities then act similarly to most of the turbulent skin friction drag reduction techniques, for instance riblets and spanwise flow oscillations. These techniques disrupt the near wall turbulent cycle hence reducing the skin friction drag [2, 3].

In the full paper the effect of the geometrical parameters (cavity spacing and diameter) on the turbulent activity and on the drag reduction mechanism will be addressed.

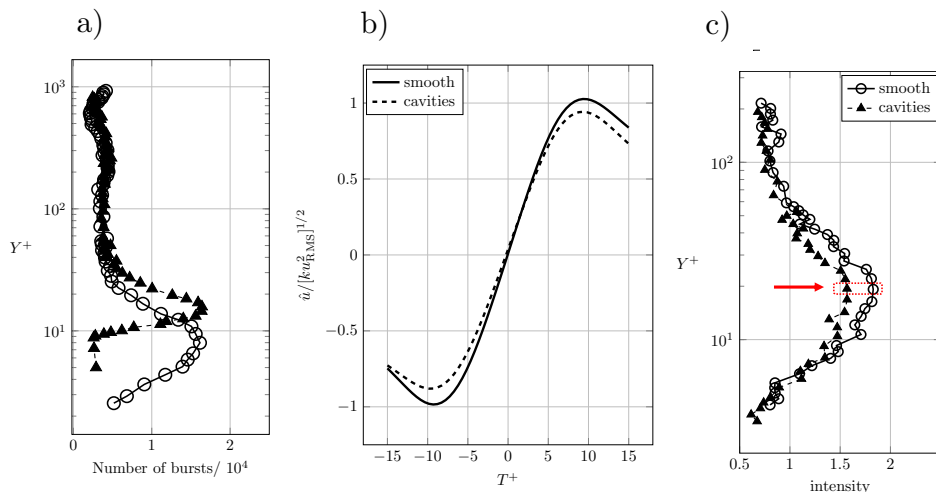


FIGURE 1. a) Number of bursts profile, b) average burst signature for smooth and perforated, c) average burst intensity profile for smooth and perforated (results for  $Re_\theta = 1440$ )

## References

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- [3] Ivan Marusic, Dileep Chandran, Amirreza Rouhi, Matt fu, David Wine, Daniel Chung, and Alexander Smits, *An energy-efficient pathway to turbulent drag reduction*, Nature Communications **12** (2021).
- [4] Pierre Ricco, Martin Skote, and Michael A Leschziner, *A review of turbulent skin-friction drag reduction by near-wall transverse forcing*, arXiv preprint arXiv:2103.04719 (2021).

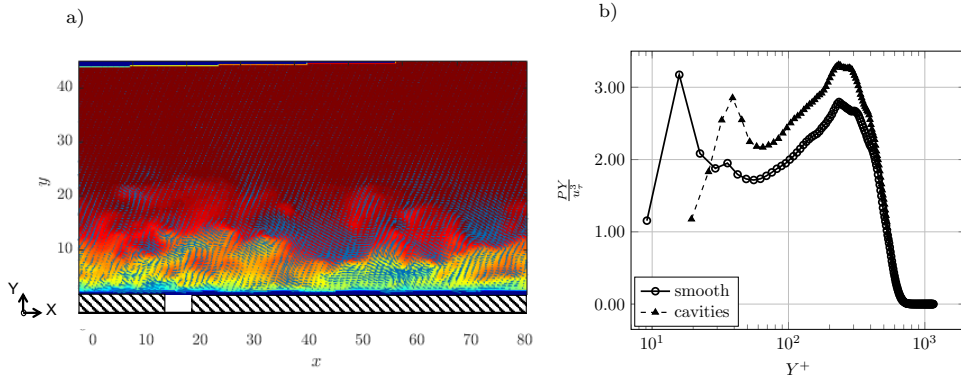


FIGURE 2. a) Contour of the instantaneous velocity field, b) production term of the TKE budget (results for  $Re_\theta = 1440$ )

- [5] Anton Silvestri, Farzin Ghanadi, Maziar Arjomandi, Ben Cazzolato, and Anthony Zander, *Attenuation of sweep events in a turbulent boundary layer using micro-cavities*, Experiments in Fluids **58** (2017).