Skin-Friction Drag Reduction Using Passive Flow Control

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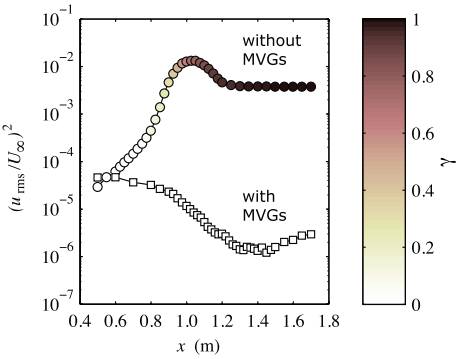

Classical vortex generators, known for their efficiency in delaying or even inhibiting boundary layer separation, are here shown to be coveted devices for transition to turbulence delay. The present devices are miniature with respect to classical vortex generators but are tremendously powerful in modulating the laminar boundary layer in the direction orthogonal to the base flow and parallel to the surface. The modulation generates an additional term in the perturbation energy equation, which counteracts the wall-normal production term, and hence stabilizes the flow. Our experimental results show that these devices are really effective in delaying transition but we also reveal their Achilles' heel. The figure shows the disturbance energy inside the boundary layer (ordinate axis) versus the downstream distance of a flat plate boundary layer (abscissa axis), with and without miniature vortex generators (MVGs). The colour map indicates the intermittency measure of the velocity time trace from 0 (laminar) to 1 (turbulent). The disturbance energy is reduced by three orders of magnitude with the MVGs mounted on the surface compared to the reference two-dimensional boundary layer case, which significantly reduces the skin-friction drag.

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Shahinfar, Sattarzadeh, Fransson & Talamelli, Revival of Classical Vortex Generators Now for Transition Delay, Phys. Rev. Lett. 109, 074501 (2012).