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Triggering Supersonic Boundary-Layer Instability by Small-Scale Vortex Shedding

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Abstract : Tripping of boundary-layers from laminar to turbulent flow, which may be necessary in specific practical applications, requires high amplitude disturbances to be introduced into the boundary layers without large drag penalties. As a possible improvement on fixed trip devices, a technique based on vortex shedding for enhancing supersonic flow transition is demonstrated in the present paper for a Mach 1.5 boundary layer. The compressible Navier-Stokes equations are solved directly using a high-order (fifth-order in space and third-order in time) finite difference method for small-scale cylinders suspended transversely near the wall. For cylinders with proper diameter and mount location, asymmetry vortices shed within the boundary layer are capable of tripping laminar-turbulent transition. Full three-dimensional simulations showed that transition was enhanced. A parametric study of the size and mounting location of the cylinder is carried out to identify the most effective setup. It is also found that the vortex shedding can be suppressed by some factors such as wall effect.

Keywords : boundary layer instability, boundary layer transition, vortex shedding, supersonic flows, flow control
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