Contribution ID: **4** Type: **Short Talk**

Topology Optimization of Roughness Elements in Boundary Layers

Tuesday, July 30, 2024 3:30 PM (20 minutes)

This article applies density-based topology optimization in order to design roughness elements capable of generating stable streaks to damp the growth of Tollmien-Schlichting (TS) waves in a boundary layer. First a steady baseflow is established, then the unsteady linearized Navier-Stokes equations are evolved to assess the spatial growth of the TS waves across the flat plate. The optimization procedure aims to minimize the TS wave amplitude at a given downstream position while a novel constraint is used promoting a stable baseflow. This method has been applied to three initial material distributions yielding three distinct and novel designs capable of damping the downstream growth of the TS wave significantly more than a reference Minature Vortex Generator (MVG) of comparable size. The optimized designs and streaky baseflows they induce are then studied a posteriori using an energy budget analysis and local stability analysis.

Relevance for Nek [100 words max]

All computations, both forward and adjoint, were performed in Nek5000. This also demonstrates the use of immersed boundary methods for design representation and optimization.

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