INTERACTION OF A THREE-DIMENSIONAL ROUGHNESS ELEMENT WITH A TS-WAVE NEAR AN AIRFOIL LEADING EDGE

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Roughness induced transition in an airfoil leading edge region can result in a loss in lift and an increase in aerodynamic drag and, therewith, in a significant performance loss. The influence of a cylindrical roughness element at different heights on a laminar boundary layer with zero pressure gradient is, therefore, investigated based on hot-wire measurements in the wake of the roughness. The laminar boundary layer is perturbed by single, two-dimensional TS-waves of different amplitude upstream of the roughness element to account for the effect of changing inflow turbulence levels. For low roughness heights, no significant influence of the roughness element on the convective boundary layer instability was observed independent of the initial (at the roughness position) TS-wave amplitude. In contrast, for medium roughness heights the TS-wave growth is very sensitive to the roughness height and considerably increased downstream of the roughness element. Therefore, three-dimensional structures with a dominant spanwise wavelength corresponding to the roughness diameter arise in the wake of the roughness element. Further downstream these three-dimensional structures are considerably damped for low initial TS-wave amplitudes. In contrast, for high initial TS-wave amplitudes energy is transferred into the higher harmonics of the fundamental excited TS-wave mode resulting in an amplification of broadband modes and finally tripping turbulence.