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Combined Roughness and Favorable Pressure Gradient Effects in a Turbulent Boundary Layer D. MIN, K.T. CHRISTENSEN, U. Illinois — The combined impact of irregular surface roughness and moderate favorable-pressure-gradient (FPG) conditions ($K \approx 2.5\times10^{-7}$) on the structure of a turbulent boundary layer is assessed using two-dimensional particle image velocimetry (PIV) measurements in the streamwise–wall-normal plane. The roughness under consideration is replicated from a turbine blade damaged by deposition of foreign materials and contains a broad range of topographical scales. These measurements are compared to measurements of smooth-wall flow under both identical FPG conditions as well as zero-pressure-gradient (ZPG) conditions in order to reveal the synergistic impact of roughness and FPG conditions on the underlying structure of the flow. While vortex organization is found to persist under both smooth- and rough-wall FPG conditions, its characteristics are altered compared to smooth-wall ZPG flow. Inspection of instantaneous velocity fields reveals this organization to be focused closer to the wall in the smooth- wall FPG case, with a shallower inclination angle noted as well as an elongated streamwise extent. In contrast, the rough-wall FPG results reveal packet structures more consistent with the smooth-wall ZPG case, indicating that roughness mitigates the FPG-induced focusing of these structural attributes toward the wall. Two-point correlations of streamwise velocity support these instantaneous observations.

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