Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

A simplified model for drag evaluation of a streamlined body with surface roughness HAOLIANG YU, UMBERTO CIRI, STEFANO LEONARDI, ARIF MALIK, University of Texas at Dallas — Atmospheric particles, raindrops, hail, or sand can cause erosion of an airfoil, especially on the leading-edge (LE) region. As the erosion becomes more severe, the lifting profile can be gradually modified, leading to increased drag and decreased aerodynamic efficiency. In wind energy, for example, LE erosion of turbine blades can significantly reduce energy production. In the present study, surface imperfections on a streamlined body are idealized as forward-facing step(s) (FFS) for which the chordwise position, spanwise width, and distribution of the steps are varied. Direct numerical simulations (DNS) are performed to understand the interactions between three-dimensional FFS and the near-wall turbulent flows. The FFS and the streamlined body are defined by the ray triangle intersection test and modeled using immersed boundary method. A reduced order model (ROM) for efficient drag prediction is derived through a set of DNS with simplified geometrical variations. Performance of the ROM is assessed by applying it to a more realistic configuration that emulates randomly shaped LE erosion, and good agreement is obtained compared to the DNS results.

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Date submitted: 07 Aug 2020 Electronic form version 1.4