Influence of leading edge surface roughness on airfoil aerodynamics

Sophie Dillon[1] & Jovan Nedić[2]
1 Department of Mechanical Engineering, McGill University, Montreal, Quebec, CANADA

Surface roughness near the leading edge of an airfoil can significantly influence boundary layer development and overall aerodynamic performance. In practical applications, such roughness may arise from surface contamination (e.g., insects or dirt), ice accretion, or material degradation due to environmental exposure. These effects are particularly relevant for aerodynamic surfaces such as aircraft wings and wind turbine blades, where leading-edge condition can strongly affect aerodynamic efficiency and stall behavior. The objective of this study is to investigate how localized leading edge surface roughness influences airfoil aerodynamics, with particular focus on its impact on pressure distribution, lift and drag characteristics, and flow separation. Wind tunnel experiments are conducted using a NACA 0012 airfoil over a range of Reynolds numbers up to 2×10^5. Surface pressure distributions are measured using pressure taps along the airfoil surface, while lift and drag coefficients are obtained from load cell measurements. Leading edge roughness is introduced using stainless steel woven wire meshes applied to the airfoil surface. The meshes differ in porosity and effective roughness height, allowing the influence of roughness geometry on aerodynamic performance to be systematically examined. Complementary experiments for Reynolds numbers up to 6×10^4 are performed in a water tunnel using particle image velocimetry (PIV) to measure the velocity field and characterize boundary layer development and flow separation. Together, these measurements provide insight into how leading edge roughness alters airfoil aerodynamics and help quantify the sensitivity of airfoil performance to variations in surface roughness.

Email address for correspondence: *sophie.dillon@mail.mcgill.ca*