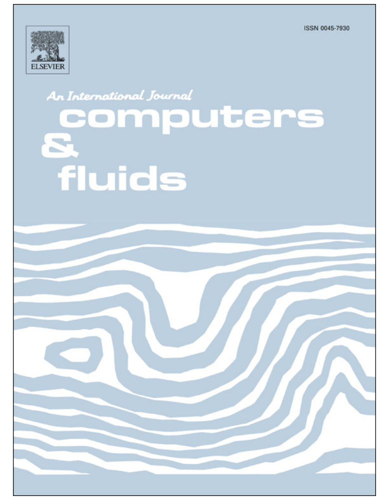
Accepted Manuscript



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PII: S0045-7930(15)00129-2
DOI: http://dx.doi.org/10.1016/j.compfluid.2015.04.014
Reference: CAF 2863

To appear in: *Computers & Fluids*

Received Date: 11 January 2015
Revised Date: 7 April 2015
Accepted Date: 14 April 2015

Please cite this article as: Zhang, W., Cheng, W., Gao, W., Qamar, A., Samtaney, R., Geometrical effects on the airfoil flow separation and transition, *Computers & Fluids* (2015), doi: http://dx.doi.org/10.1016/j.compfluid.2015.04.014

Geometrical effects on the airfoil flow separation and transition

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Abstract

We present results from direct numerical simulations (DNS) of incompressible flow over two airfoils, NACA-4412 and NACA-0012-64, to investigate the effects of the airfoil geometry on the flow separation and transition patterns at $Re = 10^4$ and 10 degrees incidence. The two chosen airfoils are geometrically similar except for maximum camber (respectively $4\%C$ and 0 with C the chord length), which results in a larger projection area with respect to the incoming flow for the NACA-4412 airfoil, and a larger leeward surface curvature at the leading edge for the NACA-0012-64 airfoil. The governing equations are discretized using an energy conservative fourth-order spatial discretization scheme. An assessment on the two-point correlation indicates that a spanwise domain size of $0.8C$ is sufficiently large for the present simulations. We discuss flow separation at the airfoil leading edge, transition of the separated shear layer to three-dimensional flow and subsequently to turbulence. Numerical results reveal a stronger adverse pressure gradient field in the leading edge region of the NACA-0012-64 airfoil due to the rapidly varying surface curvature. As a result, the flow experiences detachment at $x/C = 0.08$, and the separated shear layer transition via Kelvin-Helmholtz mechanism occurs at $x/C = 0.29$ with fully developed turbulent