Summary: A novel method is presented to calculate the deformation of a simple elastic aerofoil with a view to determining its aerodynamic viability. The aerofoil is modelled as a thin two-dimensional elastic sheet whose ends are joined together to form a corner of prescribed angle, with a simple support included to constrain the shape to resemble that of a classical aerofoil. The weight of the aerofoil is counterbalanced exactly by the lift force due to a circulation set according to the Kutta condition. An iterative process based on a boundary integral method is used to compute the deformation of the aerofoil in response to an inviscid fluid flow, and a range of flow speeds is determined for which the aerofoil maintains an aerodynamic shape. As the flow speed is increased the aerofoil deforms significantly around its trailing edge, resulting in a negative camber and a loss of lift. The loss of lift is ameliorated by increasing the inflation pressure but at the expense of an increase in drag as the aerofoil bulges into a less aerodynamic shape. Boundary layer calculations and nonlinear unsteady viscous simulations are used to analyse the aerodynamic characteristics of the deformed aerofoil in a viscous flow. By tailoring the internal support the viscous boundary layer separation can be delayed and the lift-to-drag ratio of the aerofoil can be substantially increased.

MSC:

76B10  Jets and cavities, cavitation, free-streamline theory, water-entry problems, airfoil and hydrofoil theory, sloshing
76D05  Navier-Stokes equations for incompressible viscous fluids
76M15  Boundary element methods applied to problems in fluid mechanics
74F10  Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)

Keywords:

boundary integral method; fluid-structure interaction; inviscid flow; viscous flow; Navier-Stokes equations; Chebyshev series

Full Text: DOI

References:


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