AN INVESTIGATION OF THE OSEEN DIFFERENTIAL EQUATIONS FOR THE BOUNDARY LAYER

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Abstract

The thesis is on an investigation of the Oseen partial differential equations for the problem of laminar boundary layer flow for the steady two-dimensional case of an incompressible, viscous fluid with the boundary conditions that the velocity at the surface is zero and outside the boundary layer is the free stream velocity.

It first shores-up some of the theory on using the Wiener-Hopf technique to determine the solution of the integral equation of Oseen flow past a semi-infinite flat plate. The procedure is introduced and it divides into two steps; first is to transform the Oseen equation (Oseen 1927) into an integral equation given by (Olmstead 1965), using the drag Oseenlet formula. Second is the solution of this integral equation by using the Wiener-Hopf technique (Noble 1958).

Next, the Imai approximation (Imai 1951) is applied to the drag Oseenlet in the Oseen boundary layer representation, to show it approximates to Burgers solution (Burgers 1930). Additionally, a thin body theory is applied for the potential flow. This solution is just the same as the first linearization in Kusukawa's solution (Kusukawa, Suwa et al. 2014) which, by applying successive Oseen linearization approximations, tends towards the Blasius/Howarth boundary layer (Blasius, 1908; Howarth, 1938).

Moreover, comparisons are made with all the methods by developing a finite-difference boundary layer scheme for different Reynolds number and grid size in a rectangular domain.

Finally, the behaviour of Stokes flow near field on the boundary layer is studied and it is found that by assuming a far-boundary layer Oseen flow matched to a near-boundary layer Stokes flow a solution is possible that is almost identical to the Blasius solution without the requirement for successive linearization.