Stability Properties of a Boundary Layer Flow Past a Continuously Moving Wall in a Streaming Flow

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ABSTRACT

Boundary layer flow over a wall moving with velocity $U_w(x) = U_c x^n$ and in a moving stream with velocity $U_e(x) = U_\infty x^n$ is considered. The wall is also subjected to fluid suction/injection. Self-similar boundary layer equations are derived. The existence of dual solutions in some parameter regions has been shown both analytically and numerically. There are critical values of the parameter $\lambda = U_\infty/(U_c + U_\infty)$ beyond which no physically realistic solutions are realized. The occurrence of points of inflection in the velocity profiles is observed with increase in both fluid injection and λ. Linearized stability analysis of the boundary layer flow is carried out. The governing Orr-Sommerfeld equation is solved using the Chebyshev spectral collocation method. Results show the destabilizing effect of both the fluid injection and λ to both the viscous mode resulting from solving the Orr-Somerfeld equation and the inviscid Rayleigh waves. The Rayleigh inviscid modes are unstable in only some define wave-number regimes, restabilization occurring at some higher wave-numbers. The flow is most unstable when the wall moves reversely to the free-stream.