Abstract

The stability of wall bounded shear layer at subcritical Reynolds number disturbed by a freestream convecting vortex and unsteady suction/blowing at the wall was studied. A counterclockwise line vortex was convected parallel to the plate in the direction of the free-stream, slower than the free-stream velocity and well outside the boundary layer. Simultaneously, unsteady periodic suction/blowing of the identical uid was introduced near the leading edge on the plate through a narrow slit. The incompressible unsteady problem was modelled using the vorticity stream function formulation with appropriate boundary conditions. The solution was obtained numerically. A sixth-order compact difference. scheme has been used for convection terms of the vorticity transport equation, first-order Euler for time marching and second order central differences for the stream function Poisson equation.

Simulations were performed for a range of vortex strengths (= 0, 4.5, 6.75 and 9.0) and peak velocity of suction/blowing (vmax = 0, 0:005U1, 0:01U1 and 0:05U1). This study advances previous investigations of the response to convected vortices alone. Here, a cooperative instability has been found, and the mechanism of destabilization has also been revealed. It is due to the appearance of a thin, internal shear layer originating at the leading edge, stretching downstream and lying within the boundary layer. This shear layer is susceptible to inviscid instability and sheds vortices over the plate.

In the presence of unsteady periodic suction/blowing, the shear layer was found oscillating in the frequency which is equal to that of suction/blowing and strong shedding was observed resulting in multiple separation bubbles on the plate. The response was strongly dependent on the intensity of suction/blowing, strength of the vortex and height of the vortex from the plate. In case of a strong vortex the shedding of shear layer was quick and separation bubble was formed nearer to the leading edge. In case of a weak vortex the shedding got delayed and separation bubble was observed away from the leading edge. When the suction/blowing intensity was strong, the shedding was quicker and multiple bubbles were appearing on the plate. Suction/blowing alone could not induce any separation because of the absence of the internal shear layer.